EXHIBIT C

US005995019A

United States Patent [19]

Chieu et al.

[11] Patent Number: 5,995,019

[45] Date of Patent: *Nov. 30, 1999

[54] **METHOD FOR COMMUNICATING WITH RF TRANSPONDERS**

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[73] Assignee: **Intermec I.P. Corp**

[*] Notice: This patent is subject to a terminal disclaimer.

[21] Appl. No.: **09/111,096**

[22] Filed: **Jul. 6, 1998**

Related U.S. Application Data

[63] Continuation of application No. 08/720,598, Sep. 30, 1996, Pat. No. 5,777,561.

[51] **Int. Cl.**[6] **H04Q 1/00**

[52] **U.S. Cl.** **340/825.54**; 342/42

[58] **Field of Search** 340/825.54, 572.1, 340/825.52; 342/42

[56] **References Cited**

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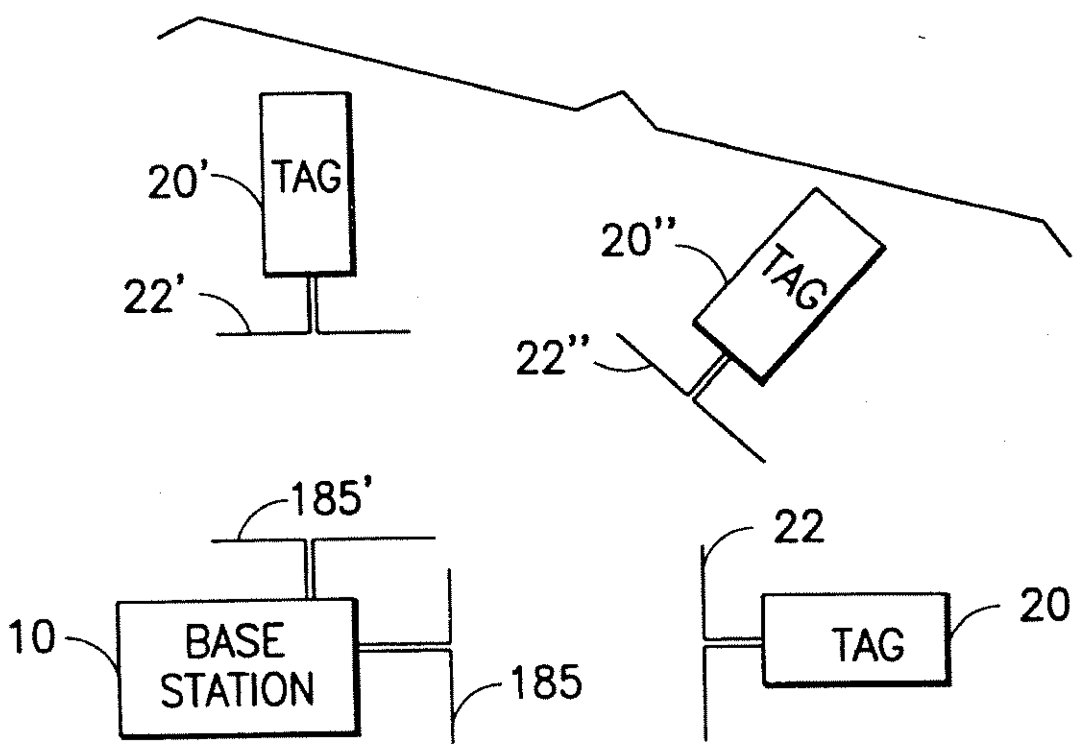
5,606,323	2/1997	Heinrich	340/825.54
5,673,037	9/1997	Cesar	340/825.54

Primary Examiner—Brian Zimmerman
Attorney, Agent, or Firm—R.T. Hodgson

[57] **ABSTRACT**

A method of selecting groups of radio frequency RF transponders (tags) for communication between a base station and the tags. The tags are selected into groups according to a physical attribute of the signal sent by the tags to the base station, or according to the physical response of the tags to a physical attribute of the signal sent from the base station to the tags. Communication with the tags is thereby simplified, and the time taken to communicate with the first tag is markedly reduced.

18 Claims, 7 Drawing Sheets



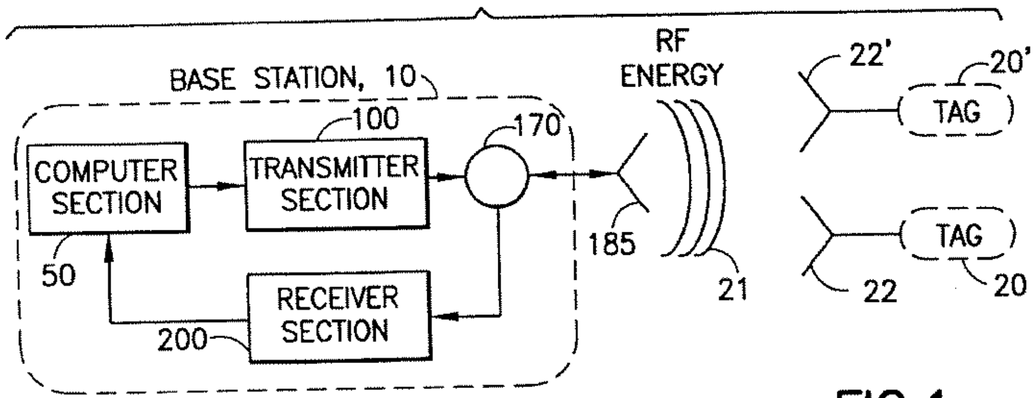


FIG.1

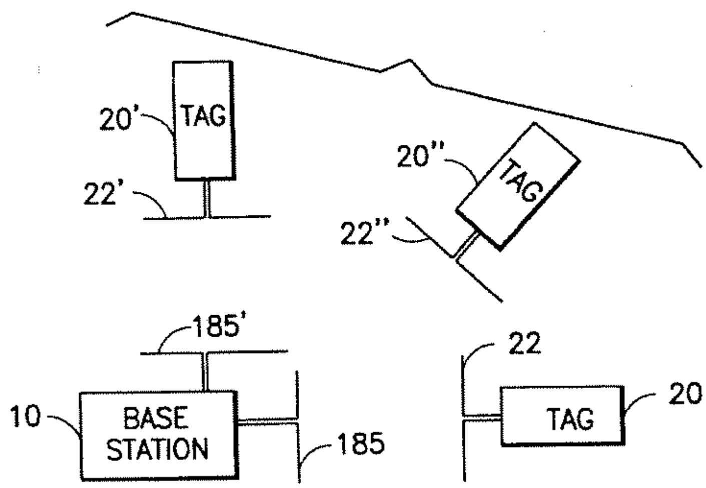


FIG.2

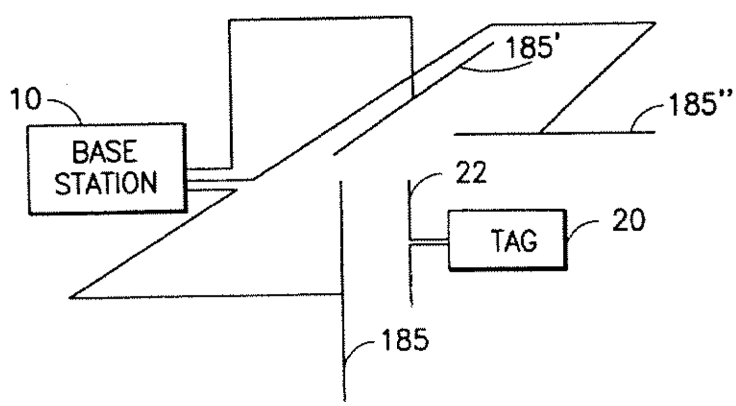
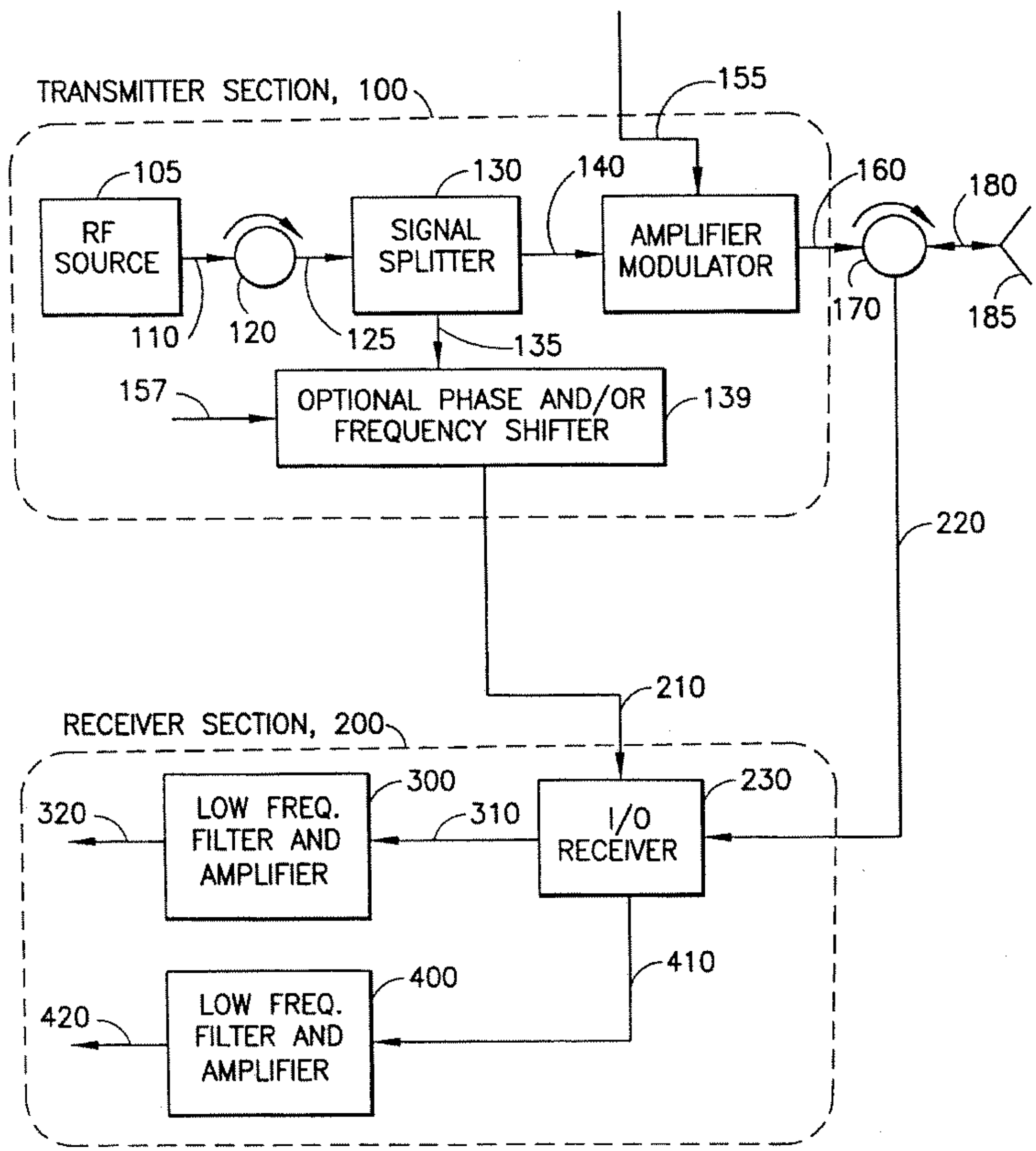


FIG.3



TRANSMITTER SECTION, 100
155
105
RF SOURCE
130
SIGNAL SPLITTER
140
AMPLIFIER MODULATOR
160
180
110
120
125
135
170
185
157
OPTIONAL PHASE AND/OR FREQUENCY SHIFTER
139
220
210
RECEIVER SECTION, 200
300
310
230
320
LOW FREQ. FILTER AND AMPLIFIER
I/O RECEIVER
400
410
420
LOW FREQ. FILTER AND AMPLIFIER

FIG.4

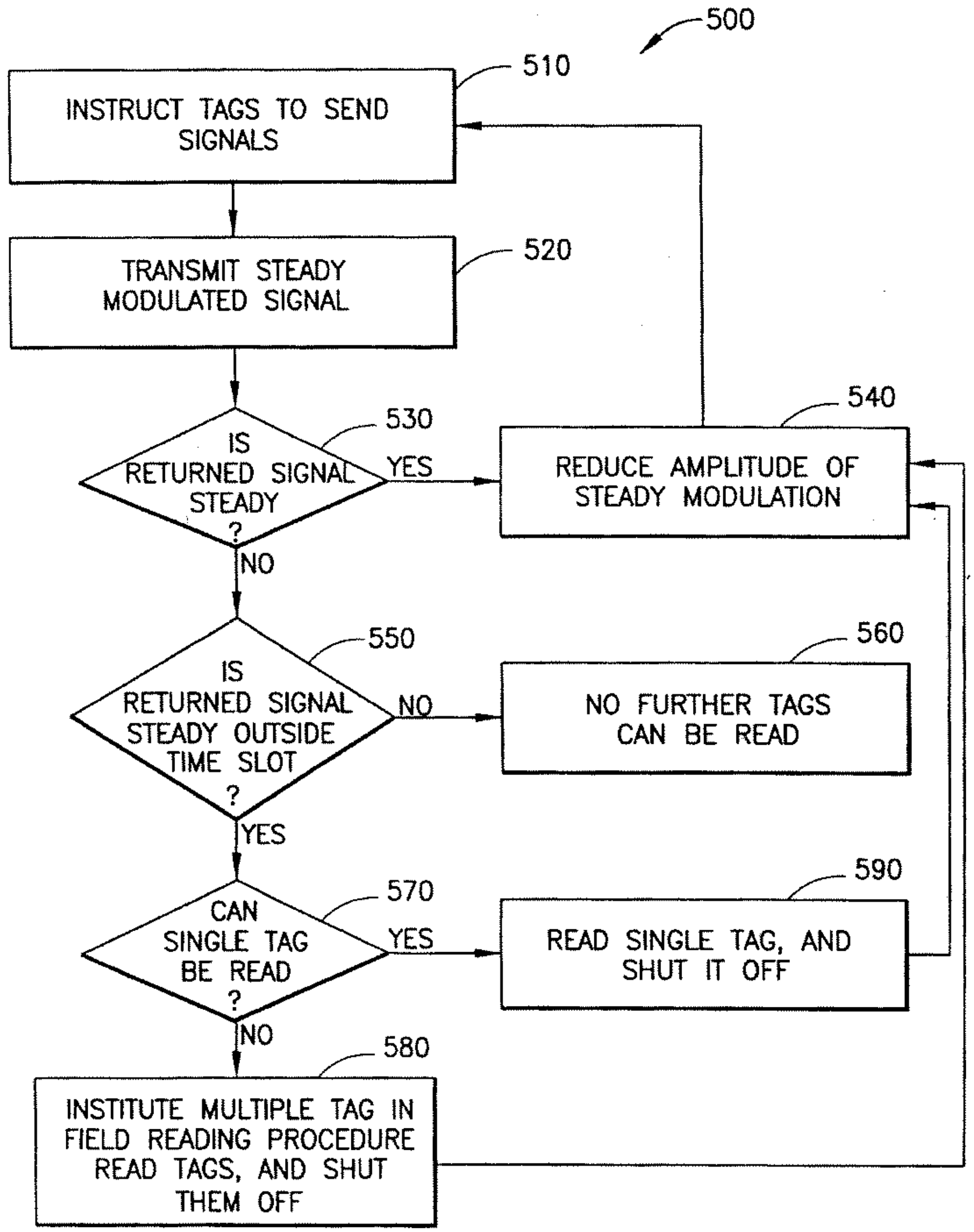
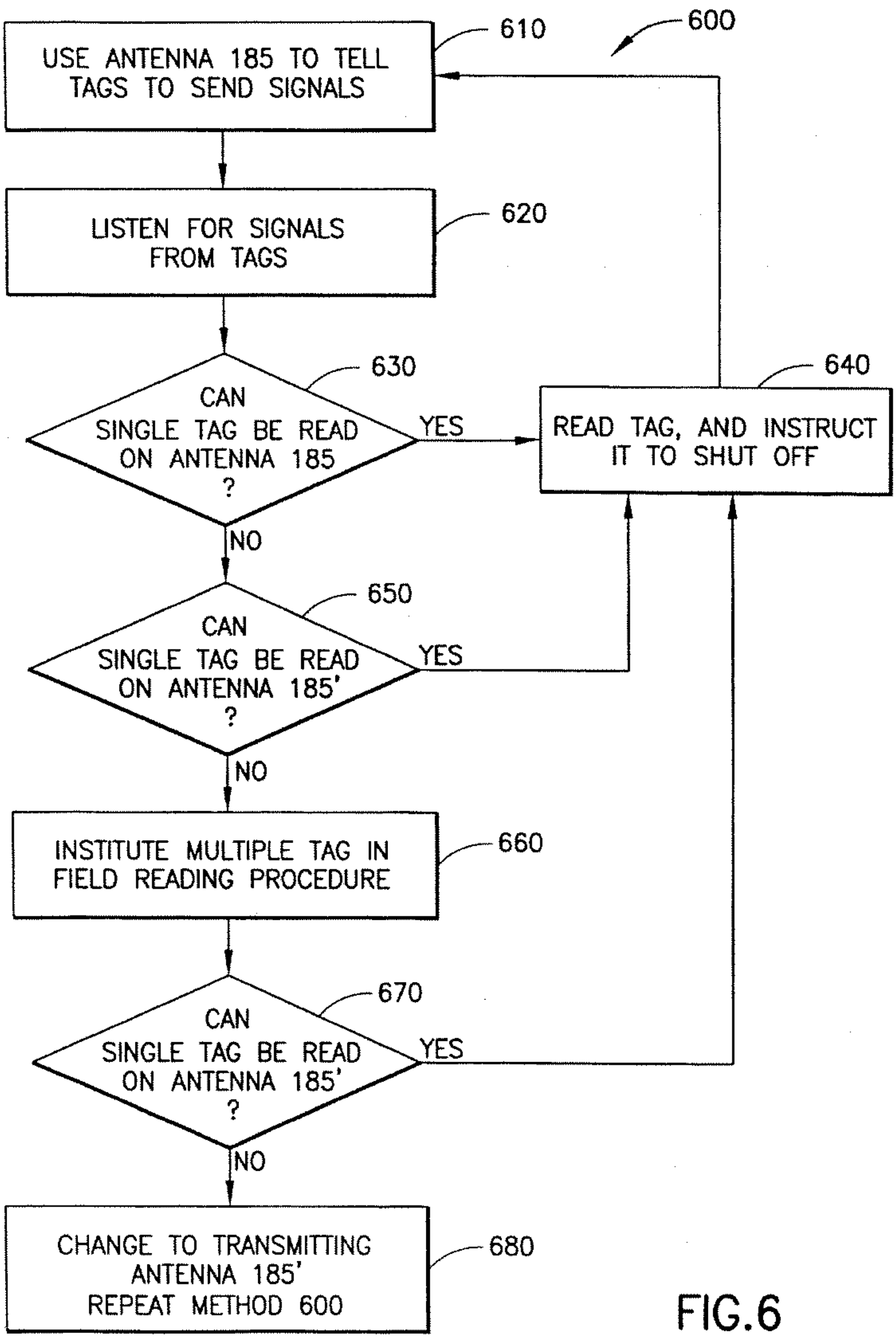

500
510
INSTRUCT TAGS TO SEND SIGNALS
520
TRANSMIT STEADY MODULATED SIGNAL
530
IS RETURNED SIGNAL STEADY ?
YES
NO
540
REDUCE AMPLITUDE OF STEADY MODULATION
550
IS RETURNED SIGNAL STEADY OUTSIDE TIME SLOT ?
NO
YES
560
NO FURTHER TAGS CAN BE READ
570
CAN SINGLE TAG BE READ ?
YES
NO
590
READ SINGLE TAG, AND SHUT IT OFF
580
INSTITUTE MULTIPLE TAG IN FIELD READING PROCEDURE READ TAGS, AND SHUT THEM OFF

FIG.5



600
USE ANTENNA 185 TO TELL TAGS TO SEND SIGNALS
610
LISTEN FOR SIGNALS FROM TAGS
620
CAN SINGLE TAG BE READ ON ANTENNA 185 ?
630
YES
NO
READ TAG, AND INSTRUCT IT TO SHUT OFF
640
CAN SINGLE TAG BE READ ON ANTENNA 185' ?
650
YES
NO
INSTITUTE MULTIPLE TAG IN FIELD READING PROCEDURE
660
CAN SINGLE TAG BE READ ON ANTENNA 185' ?
670
YES
NO
CHANGE TO TRANSMITTING ANTENNA 185' REPEAT METHOD 600
680

FIG.6

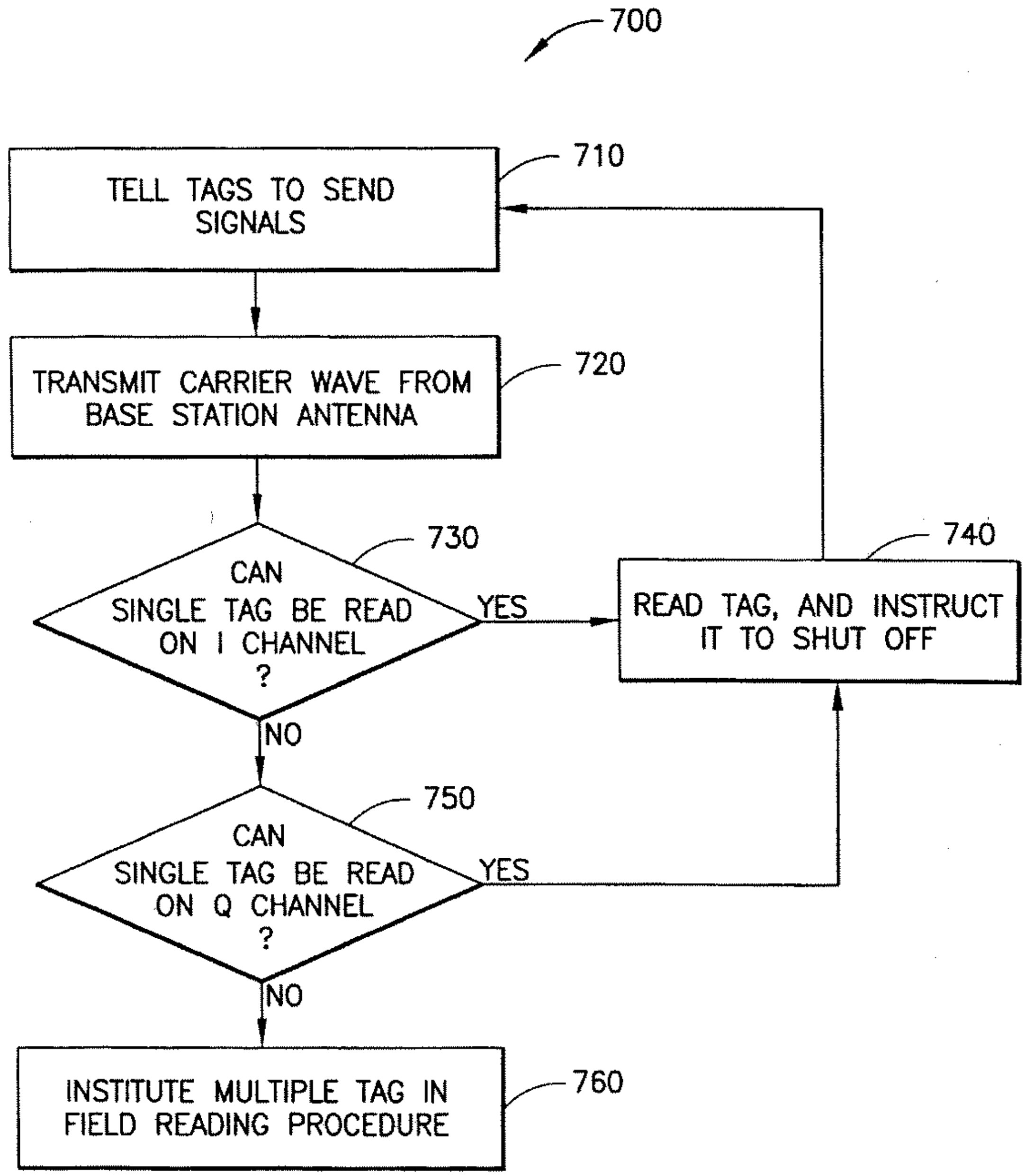
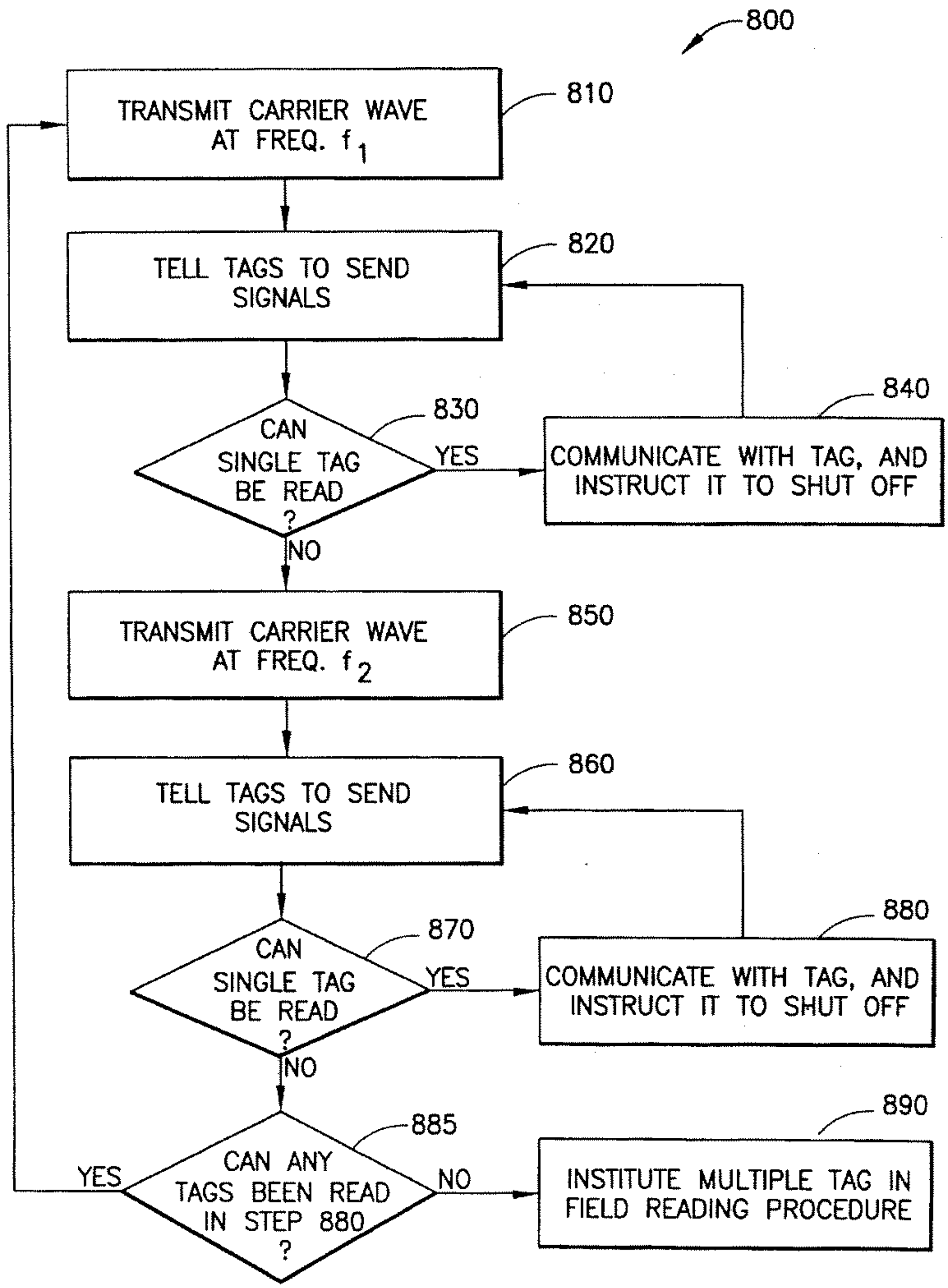

700
TELL TAGS TO SEND SIGNALS
710
TRANSMIT CARRIER WAVE FROM BASE STATION ANTENNA
720
CAN SINGLE TAG BE READ ON I CHANNEL ?
730
YES
NO
READ TAG, AND INSTRUCT IT TO SHUT OFF
740
CAN SINGLE TAG BE READ ON Q CHANNEL ?
750
YES
NO
INSTITUTE MULTIPLE TAG IN FIELD READING PROCEDURE
760

FIG.7



800
TRANSMIT CARRIER WAVE AT FREQ. f_1
810
TELL TAGS TO SEND SIGNALS
820
CAN SINGLE TAG BE READ ?
830
YES
NO
COMMUNICATE WITH TAG, AND INSTRUCT IT TO SHUT OFF
840
TRANSMIT CARRIER WAVE AT FREQ. f_2
850
TELL TAGS TO SEND SIGNALS
860
CAN SINGLE TAG BE READ ?
870
YES
NO
COMMUNICATE WITH TAG, AND INSTRUCT IT TO SHUT OFF
880
CAN ANY TAGS BEEN READ IN STEP 880 ?
885
YES
NO
INSTITUTE MULTIPLE TAG IN FIELD READING PROCEDURE
890

FIG.8

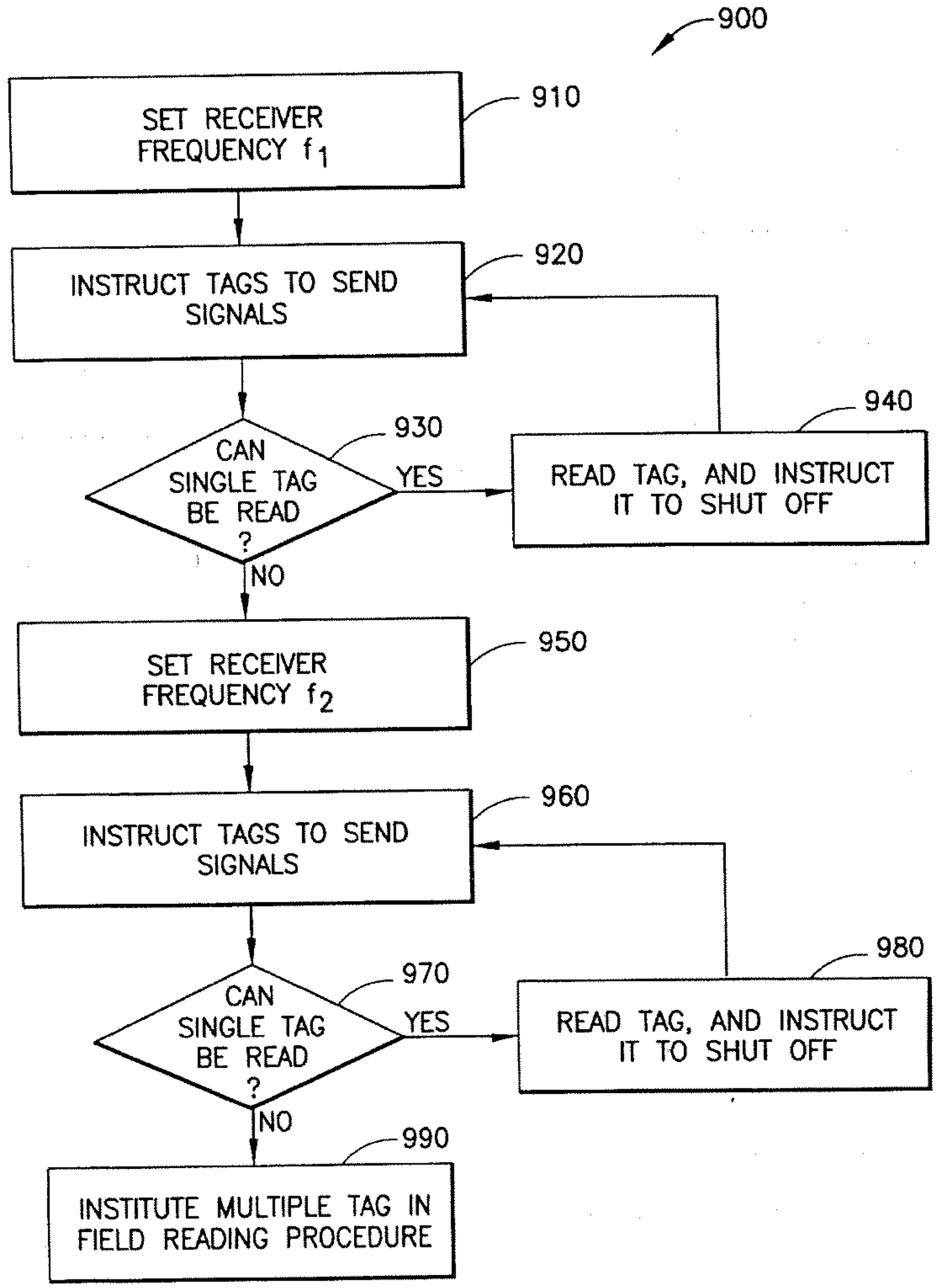

900
SET RECEIVER FREQUENCY f_1
910
INSTRUCT TAGS TO SEND SIGNALS
920
CAN SINGLE TAG BE READ ?
930
YES
NO
READ TAG, AND INSTRUCT IT TO SHUT OFF
940
SET RECEIVER FREQUENCY f_2
950
INSTRUCT TAGS TO SEND SIGNALS
960
CAN SINGLE TAG BE READ ?
970
YES
NO
READ TAG, AND INSTRUCT IT TO SHUT OFF
980
INSTITUTE MULTIPLE TAG IN FIELD READING PROCEDURE
990

FIG.9

METHOD FOR COMMUNICATING WITH RF TRANSPONDERS

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation of application Ser. No. 08/720,598, filed Sep. 30, 1996, now U.S. Pat. No. 5,777,561, issued Jul. 7, 1998.

FIELD OF THE INVENTION

The field of the invention is the field of Radio Frequency (RF) Transponders (RF Tags), wherein a Base Station sends power and information to one or more RF Tags which contain logic and memory circuits for storing information about objects, people, items, or animals associated with the RF Tags. The RF Tags can be used for identification and location (RID Tags) of objects and to send information to the base station by modulating the load on an RF Tag antenna.

BACKGROUND OF THE INVENTION

RF Tags can be used in a multiplicity of ways for locating and identifying accompanying objects, items, animals, and people, whether these objects, items, animals, and people are stationary or mobile, and transmitting information about the state of the of the objects, items, animals, and people. It has been known since the early 60's in U.S. Pat. No. 3,098,971 by R. M. Richardson, that electronic components on a transponder could be powered by radio frequency (RF) power sent by a "base station" at a carrier frequency and received by an antenna on the tag. The signal picked up by the tag antenna induces an alternating current in the antenna which can be rectified by an RF diode and the rectified current can be used for a power supply for the electronic components. The tag antenna loading is changed by something that was to be measured, for example a microphone resistance in the cited patent. The oscillating current induced in the tag antenna from the incoming RF energy would thus be changed, and the change in the oscillating current led to a change in the RF power radiated from the tag antenna. This change in the radiated power from the tag antenna be picked up by the base station antenna and thus the microphone would in effect broadcast power without itself having a self contained power supply. In the cited patent, the antenna current also oscillates at a harmonic of the carrier frequency because the diode current contains a doubled frequency component, and this frequency can be picked up and sorted out from the carrier frequency much more easily than if it were merely reflected. Since this type of tag carries no power supply of its own, it is called a "passive" tag to distinguish it from an active tag containing a battery. The battery supplies energy to run the active tag electronics, but not to broadcast the information from the tag antenna. An active tag also changes the loading on the tag antenna for the purpose of transmitting information to the base station.

The "rebroadcast" of the incoming RF energy at the carrier frequency is conventionally called "back scattering", even though the tag broadcasts the energy in a pattern determined solely by the tag antenna and most of the energy may not be directed "back" to the transmitting antenna.

In the 70's, suggestions to use tags with logic and read/write memories were made. In this way, the tag could not only be used to measure some characteristic, for example the temperature of an animal in U.S. Pat. No. 4,075,632 to Baldwin et. al., but could also identify the animal. The antenna load was changed by use of a transistor.

Prior art tags have used electronic logic and memory circuits and receiver circuits and modulator circuits for receiving information from the base station and for sending information from the tag to the base station.

The continuing march of semiconductor technology to smaller, faster, and less power hungry has allowed enormous increases of function and enormous drop of cost of such tags. Presently available research and development technology will also allow new function and different products in communications technology.

U.S. Pat. No. 5,214,410, hereby incorporated by reference, teaches a method for a base station to communicate with a plurality of Tags . The tags having a particular code are energized, and send a response signal at random times. If the base station can read a tag unimpeded by signals from other tags, the base station interrupts the interrogation signal, and the tag which is sending and has been identified shuts down. The process continues until all tags in the field have been identified. If the number of possible tags in the field is large, this process can take a very long time. The average time between the random responses of the tags must be set very long so that there is a reasonable probability that a tag can communicate in a time window free of interference from the other tags.

RELATED APPLICATIONS

Copending patent applications assigned to the assignee of the present invention and hereby incorporated by reference, are:

Ser. No. 08/303,965, filed Sep. 9, 1994 entitled RF Group Select Protocol, by Cesar et al, now U.S. Pat. No. 5,670,037;

Ser. No. 08/304,340, filed Sep. 9, 1994 entitled Multiple Item RF ID protocol, by Chan et al, now U.S. Pat. No. 5,550,547;

Ser. No. 08/521,898, filed Aug. 31, 1995 entitled Diode Modulator for RF Transponder by Friedman et al, now U.S. Pat. No. 5,606,323;

application submitted Aug. 9, 1996, entitled RFID System with Broadcast Capability by Cesar et al; and

application submitted Jul. 29, 1996 entitled RFID transponder with Electronic Circuitry Enabling and Disabling Capability, by Heinrich et al.

These applications teach a communications protocol whereby a base station communicates to a plurality of tags by polling the tags and shutting down tags in turn until there is just one left The information is then exchanged between the base station and the one tag, and then the one tag is turned off. The unidentified tags are then turned on, and the process is repeated until all the tags have the communication protocol completed. Typical protocols requires a time which is not linearly proportional to the number of tags in the field More tags take a longer time per tag than fewer tags. If the tags can be selected into groups in some way, each group can be dealt with in a shorter time per tag, and the time taken to communicate with the first tag is markedly shortened.

SUMMARY OF THE INVENTION

The method of the present invention is a method of selecting groups of RF tags for a communication protocol comprising selecting a plurality of groups of tags according to a physical attribute of the signal sent by the tags to the base station, or selecting the groups according to the physical response of the tags to a physical attribute of the signal sent from the base station to the tags, and communicating

with the tags in each group. A single tag may be a member of one or more groups. Some groups may have no members. The most preferred embodiment of the invention is the method of selecting groups on the basis of the physical signal strength of the RF signal received from the tags by the base station. The tags have greater or less received signal strength depending on the distance to the base station antenna, the relative orientation of the tag and the base station antennas, and the local conditions of reflectors and absorbers of radiation around the tag. The base station may also select groups of tags according to the polarization or the phase of the returned RF signal, the RF carrier or Doppler shifted RF carrier or modulation frequency sent by the tags, or any another physical signal from the tags. The base station may also select groups of tags according to the physical response of the tags to the polarization, phase, carrier frequency, modulation frequency, or power of the RF signal sent by the base station. The communication protocol can be carried out simultaneously or sequentially with the selected groups. The physical characteristics used to group the tags can be measured simultaneously or sequentially. Different groups may be selected by taking the union, the intersection, or other combinations of the various groups of tags selected according to the different physical attributes. The tag group selection parameters may also include selecting groups by software, i.e. by selecting the groups according to information stored on the tag.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a generalized diagram of a base station communicating to one or more tags.

FIG. 2 is a diagram of a base station having two antennas for receiving information about the polarization of the signal sent by a tag.

FIG. 3 is a diagram of a base station having three antennas for receiving information about the polarization and phase position of the signal sent by a tag.

FIG. 4 is a diagram of a base station circuit which can select the strongest signals from signals sent by a plurality of tags.

FIG. 5 is a flow chart of the most preferred embodiment of the invention.

FIG. 6 is a flow chart of a preferred embodiment of the invention.

FIG. 7 is a flow chart of a preferred embodiment of the invention.

FIG. 8 is a flow chart of a preferred embodiment of the invention.

FIG. 9 is a flow chart of a preferred embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 sketches abase station **10** sending RF energy **21** and information to one or more tags **20**. The tags **20** may have varying distances from the base station, and the tag antennas **22** may be in any orientation with respect to the base station antenna. The base station comprises a transmitter section **100**, a computer section **50**, a circulator **170**, a receiver section **200**, and one or more antennas **185**.

FIG. 2 depicts a base station **10** which can group the tags **20** into groups on the basis of polarization of the RF radiation back scattered to the base station **10**. The base station **10** has two perpendicular antennas **185** and **185'** communicating with three tags **20, 20'**, and **20"**. The antennas **185** and **185'**, and **22, 22'** and **22"** are depicted as simple dipole antennas which transmit linearly polarized radiation with the polarization substantially parallel to the antennas. In the diagram shown, antenna **185** may communicate well with the tag **20** having an antenna **22** parallel to antenna **185**, less well with the antenna **22"** which is shown having a 45 degree orientation with respect to antenna **185**, and not at all with the tag with a perpendicular antenna **22'**. The groups are first selected on the a basis of the response of the tags to the polarization of the signal sent out from the base station. In this example, two groups are selected: those tags which respond to the particular polarization, and those tags which do not respond. In the embodiment depicted in FIG. **2**, a signal sent out from antenna **185** brings responses from tag **20** and from tag **20"** to antenna **185**, and from tag **20"** alone to antenna **185'**. The tag antenna **22'** may not receive power from the perpendicular antenna **185**, and so tag **20'** remains silent. The tags are then further selected into subgroups according to the polarization of the returned signal. Thus, three groups of tags are selected by this method in this example, tag **20'** is in one group of "silent" tags, tag **20"** is in the group which is picked up by antenna **185'** because the polarization of the signal from tag **20"** can be detected by antenna **185'**, and tags **20** and **20"** are in the group with polarization components which may be picked up by antenna **185**. Communication with each of the two "non silent" groups in turn or in parallel simplifies and speed the communication protocol. In particular, the time taken to communicate with the first tag is markedly reduced. In the example given above, the signal returned to antenna **185'** is the signal from only a single tag **20"**, and that tag can return the tag identification number while the antenna **185** receives signal signifying more than one tag in the field. The tag **20"** may then be turned off for the duration of the communication procedure, and the process repeated to identify and shut down tag **20**. The sending antenna is then switched to antenna **185'**, and the remaining tag **20'** is identified. While a linear polarization scheme is shown as an example, it is clear to one skilled in the art that circularly polarized signals could also be used with good effect. The exact orientations of the antennas are also not critical to the invention, as long as there is a difference in the sensitivity of the antennas to the polarization of the RF signals sent by the tags. A single base station antenna could be used, as long as the polarization characteristics of the single base station antenna could be changed by the base station or by other means.

FIG. **3** shows a base station **10** with more than two dipole antennas **185, 185'**, and **185"**. In this example, each antenna axis is mutually orthogonal so that the orientation of the linearly polarized backscattering from dipole antennas **22** in the field can be measured and the tags selected into groups for the communication procedure.

FIG. **4** shows a block diagram for circuitry which can allow the base station to select a group of tags by the signal strength received at the base station. The equipment for implementing the method of the most preferred embodiment of the invention uses five sections of the base station **10**: a computer section **50**, a transmitter section **100**; a receiver section **200**; a hybrid coupling device **170**; and an antenna **185**. The computer section may be a relatively unsophisticated circuit for controlling the transmitter and for receiving signals from the receiver, or it could include highly sophisticated workstations for interrogating and writing information to the tags. The transmitter section **100**, under control of the computer section **50**, sends a signal of the appropriate amplitude and frequency (which may or may not be modulated) to the hybrid **170**, which sends the (modulated)

signal to the antenna **185**. The preferred modulation for communication to and from the tags is amplitude modulation, but it may be either frequency or phase modulation. The antenna **185** both sends out the RF carrier frequency which may or may not be modulated, and captures the signals radiated by the tags **20**. The antenna **185** captures the signals radiated by the tags and sends the signals back to the hybrid **170**, which sends the signals to the receiver section **200**. The receiver section down converts and extracts the modulated signal from the carrier, and converts all the modulation energy it receives to a baseband information signal at its output. In the most preferred embodiment, the receiver has two outputs in quadrature called I (in phase with the transmitted carrier) and Q (quadrature, 90 degrees out of phase with the carrier). However, various embodiments of the invention have just one output. The hybrid element **170** connects the transmitter and receiver to an antenna while simultaneously isolating the transmitter and the receiver from each other. That is, the hybrid allows the antenna to send out a strong signal from the transmitter while simultaneously receiving a weak backscattered reflection. The strong transmitted signals being sent into the antenna must be eliminated from the receiver by the hybrid.

The transmitter section depicted by block **100** provides the energy and frequency signals for the transmitter carrier and the receiver down converter, and the amplified and modulated signal **160** which may be sent by the antenna **185**. The RF source **105** of signal **110** is usually isolated by an element **120** between the carrier signal source **105** and the rest of the circuit which avoids coupling problems of coupling reflections back to the RF source. The isolation element **120** is usually a circulator with one port terminated by a resistor. The isolated carrier signal **125** is split into two paths in a signal splitter element **130**. Most of the energy **140** goes to an amplifier modulator element **150**, while signal **135** takes a small signal to the receiver section depicted by block **200**. An optional phase and/or frequency shifter element **139** may be included between the signal splitter **130** and the receiver section **200** to provide control by the computer section **50** over line **157** of the reference phase and frequency signal **210** which the receiver section uses in detecting the signals from the tags. The phase and or frequency shifter **139** may send out signals differing by a small amount in frequency from the signal **110** sent out from the RF source **105**, or it may send out harmonics of the signal. In the amplifier modulator section **150**, the carrier frequency is amplified and modulated by a signal **155** controlled by computer section **50**. A preferred embodiment has a carrier frequency greater than 400 MHZ. A more preferred embodiment has a carrier frequency greater than 900 MHZ. The most preferred embodiment uses a carrier frequency of from 2.3 to 2.5 Ghz, and this signal is amplitude modulated at 20–60 kHz. In the preferred embodiment, a direct modulation of the carrier frequency is depicted However, an up converter of multiple frequencies may also be used. This modulated signal **160** enters the hybrid element **170** and is passed over lead **180** to the antenna **185**. A modulator signal is applied at **155** into the modulator **150** to give a modulation which may be amplitude, frequency or phase modulation. The most preferred embodiment is amplitude modulation.

In the receiver section **200**, the received signal from the antenna **185** travels along lead **180** and enters the hybrid **170** which directs the signal along **220** to the receiver section depicted by block **200**. This signal comprises signals sent by the tags, which modulate the carrier frequency at a frequency of; for example, 40 KHz, and the reflected unmodulated transmitter carrier signal reflected from the antennas or other reflectors in the field. The antenna will never be perfectly matched to the transmitter, and will reflect a signal which is about 20 dB down from the signal transmitted by the antenna. Of course, the carrier signals reflected by the tags, and the various reflections of the transmitted signal, will be much weaker than the signal transmitted from the antenna. The receiver structure **230** of the most preferred embodiment here is a direct down conversion I and Q system where the mixing frequency signal **210** is generated by the source **105** and is the only send-out by the transmitter. The single down conversion system receiver removes the carrier frequency signal and generates two baseband signals which have frequencies in the 40 KHz region in quadrature **310** and **410**. These signals are filtered and amplified by means of signal processing in elements **300** and **400**. The signals **320** and **420** are passed to the computer section **50** for further processing.

The hybrid component **170** is typically a circulator. It passes signals from 160 to 180, from 180 to 220, from 220 to 160 but not the other way around. Hence the transmitter is isolated from both the small amount of modulated carrier reflected by the antenna **185** (20 dB down typically) and the circulator (20 dB leakage typically). The receiver is isolated from the large signal sent from the transmitter **100** to the antenna **185**, and receives about −20 dB signal from leakage from the circulator 170 and a further −20 dB of signal from the reflection from the antenna.

Of course, when the base station modulates the carrier signal to transfer information from the base station to the tags, the reflected modulated signals from the antenna and the leakage from the circulator will swamp out any signals sent by the tags. In the prior art the tags communicate in a time period when there is no modulation of the carrier signal transmitted from the base station, or the tags communicate at a different carrier frequency than that transmitted by the base station, so that the receiver can pick out the modulated signals from the tags from all the reflections and leakages of the carrier signals. The present invention allows simple discrimination of signals by the tag to the base station sent as modulation of the base station carrier frequency, or as modulations of another frequency, from one or more tags, and allows the tags to be sorted in groups determined by the tag signal strength received at the base station.

The most preferred embodiment of the present invention is a method to sort the tags into groups by sending a steady, weak signal modulation at the communication modulation frequency to the tags in the time period where the prior art sends an unmodulated carrier signal so that the tags may communicate back to the base station. The steady, weak modulation frequency is not strong enough to influence the tag, but is strong enough so that the steady, weak modulated signals reflected from the antenna **185** and leaked around the hybrid **170** can be measured by the receiver and can be used to set a level for discriminating amongst the tag signals. In the most preferred embodiment, the communication to the tags is carried out by a 100% amplitude modulation of the carrier frequency at a 20–60 Khz frequency. The preferred protocol for the tags to detect such information is a 50 dB on/off ratio, but this is not necessary to the invention. Any modulation of the carrier frequency which can conceivably be used for communication between the tags and the base station can be used. Such modulations as frequency modulation and phase modulation are well known in the art. In the present invention, a modulation amplitude less than that used to communicate with the tags is impressed on the outgoing carrier wave. The mismatch at the antenna will

always cause that signal to be reflected and to be present at the receiver. This signal is detected at the receiver and is used to establish a deterministic signal floor. As backscattered modulated signals are received and are stronger than this coupling signal, the received back scattered signal dominates the receiver. Hence, a high sensitivity receiver may be used with a forced coupled modulation from the transmitter as its signal noise floor, and behave in a predictable manner between the conditions of no tags in the field, a single tag in the field, multiple tags in the field, and interference. Furthermore, by varying the modulation strength of the weak, modulated signal, the returned signal strength of signals from the tags required to overcome the coupled modulator signal is increased or decreased thereby allowing the base station to select a group of tags based on the returned signal strength.

FIG. 5 depicts a flow chart **500** of the most preferred method for selecting groups of tags and communicating with the tags in each group. A modulation frequency of 40 Khz is chosen as an example. At step **510**, the base station transmits a modulated signal to the base station antenna, and hence to the tags, instructing the tags to respond and return a modulated signal in a time period (time slot) defined by the tag communication protocol. At step **520**, the base station transmits a carrier wave to the base station antenna The carrier wave has a steady 40 Khz amplitude modulation which is less than that required to communicate with the tags. The base station measures the 40 KHZ modulation received from the base station antenna in the time slot defined by the tag communication protocol. If the modulated signal received by the receiver **200** is steady in step **530**, the reflected modulated signal and leakage is greater than any signals received from tags, which would send an unsteady modulated signal. The base station then reduces the amplitude of the steady modulated signal in step **540** and the system returns to step **510**. If the modulated signal is not steady in step **530**, the base station checks at step **550** to see whether the modulated signal returned is steady outside the time slot defined by the tag communication protocol. If the modulated signal is unsteady when no tags are supposed to be sending signals, the unsteady signal is noise, and the receiver can not distinguish between signals sent by the tags and the noise. No tags are in reading position in the field, and the protocol is ended in step **560**. If however the modulated signal is steady outside the time slot, and unsteady in the time slot, one or more tags in the field are sending signals. These signals are stronger than the steady modulated signals received from the reflected steadily modulated carrier wave. If a single tag is in the field, and can be read at step **570**, the single tag is read and instructed to shut off, at step **590**, and the system is returned to step **540** to reduce the steady modulation and return to the beginning step **510** to try to find tags with less signal strength. If more than one tag is in the field and the tag signals interfere with each other so that they can not be read at step **570**, a multiple tag reading protocol is instituted in order to read the multiple tags at step **580**. The tags are read using the multiple tag reading protocol, and ordered to shut down, and the system is returned to step **540** to reduce the steady modulation and return to the beginning step **510** to try to find the group of tags with less signal strength than the first group.

Step **550** is preferably taken after step **530**, but step **550** may optionally be taken between steps **570** and **580** or after step **580** if no tags are read by the multiple tag reading procedure.

The most preferred embodiment of the invention uses a protocol in which the tags are commanded to return an identification signal in a particular time slot, but the same invention may be used where the tags are commanded to return information in any defined time periods.

While the preferred embodiment uses the naturally occurring reflections from the base station antenna **185** and leakage from the hybrid **170** to introduce the noise floor signal into the receiver **200**, many other means of introducing this signal to the receiver are possible to one skilled in the art. As an example, the steady 40 Khz modulation could be summed with the signals from the I/Q demodulator coming on lines **310** and **410**, or indeed a specially constructed device analogous to a two input I/Q demodulator could be constructed to accept the steady 40 Khz comparison signal from an outside source.

Additional embodiments of the invention include further subdividing the groups selected by the above method on the basis of the phase and/or polarization of the signals returned to the base station, as well as other physical or software group selection criteria.

A preferred embodiment of the invention is to select tags on the basis of the returned polarization of the signals. In the embodiment shown in FIG. **2**, groups of tags with antennas which return a linear polarization which is polarized more parallel to one or the other of the two dipole antennas **185** or **185'** sketched in FIG. **2** are selected. Returned signals from the two antennas are processed in parallel by two sets of receiver circuitry like that shown in FIG. **4**. The tags are interrogated by transmitting the modulated carrier signal from first one antenna **185**, then the other antenna **185'**, and four channels of signals (the I and Q channels received from each antenna) may be processed in parallel or in sequential fashion. This set up would select the tags into 8 groups, which of course may be further selected and grouped on the basis of the received signal strength or any other physical or software attribute.

FIG. **6** depicts a flow chart **600** of the preferred method of selecting groups of tags on the basis of the polarization of the signals returned to the base station. As an illustrative example, a base station comprising 2 antennas which are sensitive to different polarizations, such as depicted in FIG. **2**, is chosen. However, the number of antennas and whether the polarization is linear, circular, or some combination of the polarizations may be chosen at will by one skilled in the art. Step **610** uses antenna **185** to send a signal to the tags instructing the tags to return a signal in the time slot determined by the communication protocol. The antenna **185** is then used to listen for signals from the tags in the time slot where the tags return signals in step **620**. Signals retuning from antenna **185** are analysed in step **630** to see if the base station can read the signal. If the signal is returned from a single tag, the base station communicates with the single tag in step **640**, and instructs the tag to shut itself down for the remainder of the communication protocol, or until it is specifically instructed to start returning signals again. The system is then returned to step **610** to look for more tags. If the signal returned by the tags to antenna **185** can not be read, either because there are no tags in the field in a position to be read by antenna **185** or because there multiple tags trying to communicate at the same time, the system may then try to read a single tag communicating to antenna **185'** in step **650**. If a single tag is successfully read, the system reads the tag at step **640**, shuts the tag down, and returns to the beginning step **610** to try to read again the tags which may be tying to communicate to antenna **185**. Since there is now one fewer tag in the field, a tag may now be read at step **630** on antenna **185**. If a single tag can not be read in step **650**, a multiple tag in the field reading procedure is

instituted in step **660**. Steps **630** and **650** may be taken either sequentially or simultaneously, if two receivers are connected to the two antennas. If tags are read using one antenna in step **660**, the system decides in step **670** to communicate with the tags and turn them off and the system returns to step **610** to try to read a single or multiple tag from the other antenna If the multiple tag reading procedure does not read any tags from either antenna in stop **660**, the system may switch transmitting antennas in step **680**, so that the commands and carrier wave are transmitted to antenna **185'** instead of antenna **185**. The method **600** of the invention can then be used to identify and select other groups not found in the first application of method **600**. Alternatively, the system may switch transmitting antennas between steps **650** and **660** to try to find, communicate with, and shut off single tags.

Another antenna perpendicular to the two antennas shown in FIG. **2**, which is placed remotely from the base station as shown in FIG. **3** allows all combinations of linear polarized backscattering to be discriminated and allows the selecting of groups based on all polarizations of the received signal.

The three antennas **185**, **185'**, and **185"** shown in FIG. **3** allow many more groups to be selected on the basis of phase information. A possibly different group responds in the I and Q channels of the receiver of each antenna, and the groups may be different depending on which antenna or combination of antennas sends the carrier signal to the tags. Such group selection markedly cuts down the time needed to interrogate many tags in the field.

Base station antennas and tag antennas sensitive to circular and other polarizations are also known in the art, and these also may be used by one skilled in the art in an analogous way to that shown in FIGS. **1**, **2**, and **3** and described above.

An additional preferred embodiment of the invention is to use the information on the I and Q channels to select tags into groups on the basis of the phase of the returned signal which is dependent on the distance of the tags from the base station. As a tag is moved away from the base station, the carrier signal from the tag received at the base station changes from being in phase with the transmitted signal to being 90 degrees out of phase to being 180 degrees out of phase as the tag is moved one quarter of a wavelength of the RF EM field. The amplitude in the I channel and the Q channel changes accordingly, for example from a 1 in the I channel and a 0 in the Q channel, to a 0 in the I channel and a 1 in the Q channel, to a −1 in the I channel and 0 in the Q channel respectively. Thus, selecting the signals received from the tags on the I channel alone selects a group of tags for communication, while selecting the signals received from the tags on the Q channel selects a different group of tags which are at different distances from the base station antenna. Both the I and the Q channels may be used simultaneously or sequentially to communicate with the two different groups of tags. It is possible that some tags may be in both groups at the same time. As long as there are some tags in one group and not in the other, the selecting of the groups speeds up the tag communication protocol.

FIG. **7** gives a flow chart of a preferred method **700** of selecting groups of tags by the phase of the signal returned to the base station. A signal **710** is sent from the base station to the tags instructing the tags to return modulated signals to the base station in the time slot designated for tag response. In this time period, a steady carrier wave having a defined phase is transmitted **720** from the base station antenna. If a single tag can be read on the receiver I channel **730**, the tag

is instructed to shut itself off in step **740** and the system returns to step **710**. If a single tag can not be read on the I channel in step **730**, the system tries to read a single tag in the Q channel in step **750**. If a single tag can be read step **750**, the tag is instructed to shut itself off in step **740**, and the system returns to the beginning **710** to try to pick up a single tag in the I channel. If single tags can not be read in either the I channel or the Q channel, the system decides in step **750** to institute the multiple tag in field reading procedure **760**. If tags are identified in either I or Q channels in step **760**, the system may shut the identified tags off and return to step **710** to try to find single tags grouped in the other channel.

While the above method **700** has steps **730** and **750** proceeding sequentially, it is well within the scope of the invention that steps **730** and **750** may also be carried out simultaneously. If a single tag is read on either the I channel or the Q channel, the system returns to step **710**. If no single tags are read on steps **730** and **750**, the system proceeds to step **760**. In step **760**, if tags are identified and shut off, the system may at any time return to step **710** to carry out the simpler subgrouping.

With the addition of an optional phase shifting element **139**, signals from a particular tag are brought entirely into the I channel or the Q channel. The tags may then be sorted into many more groups than the two groups defined by the I and Q channels as explained above. If only one channel of information, for example the I channel, is used, changing the phase shifting element **139** to give a series of different phase delays may sort the tags into more groups. The computer section **50** may end the phase shift element **135** instructions over line **157** to shift phase by, for example 0, 30, 60, and 90 degrees which would select four different groups of tags for communication. Using both the I and Q channels, and 3 phase shifts of 0, 30, and 60 degrees gives 6 groups as another example.

If the carrier signal frequency sent out from the base station is changed, a particular tag will be a different number of quarter wavelengths from the base station and the signal will be distributed in a different way between the I and Q channels of the base station receiver. A preferred embodiment of the present invention is to select different groups of tags according to the response of the tag to such a frequency shift of the base station. FIG. **8** gives a flow chart for the method **800** of selecting groups of tags on the basis of the response of the tag to the frequency of the carrier signal sent out from the base station. In step **810**, the base station sends out a carrier wave having a first frequency f_1. In step **820**, the base station instructs the tags to return signals. The signal returning to the base station is analyzed in a single channel of the receiver in step **830**. If the signal can be read, the tag is communicated with and turned off in step **840** and the system returns to step **820** to find single tags which may have less received signal strength than the tag found in the previous cycle. If no tag is found in step **830**, the system then changes the carrier frequency sent out from the base station in step **850** to a frequency f_2, and then sends signals to the tags to return signals in step **860**. If a single tag can be read in step **870**, the tag is communicated with and shut off in step **880**, and the system returned to step **860**. If no tags are found in step **870**, the system checks to see if any tags have been found in previous cycles through step **870**, and if so the system is returned to the beginning step **810** to search the first frequency again If no tags have been found in previous cycles, the system goes to the multiple tag in the field search procedure **890**. While two frequencies are used in this example, the method is not limited to the use of just two

frequencies, and many more could be used. Use of any plurality of frequencies which shift the relative phase of the returned signal is contemplated by the inventors.

A further embodiment of the invention is to select the tags into groups on the basis of the frequency response of the tags. Tags responsive to different carrier frequencies are interrogated, and the base station is programmed to shift from one frequency to the next to select and interrogate these different groups of tags in a sequential fashion. Tags may be grouped into tags which respond to 900 MHZ, and tags which respond to 2.4 MHZ, as an example.

A further embodiment of the invention is to select the tags into groups on the basis of the response of the tags to the RF power transmitted from the base station. The method of the embodiment is to send a low power to the set of tags, and communicate with the set of tags which respond to the low power, then turn the tags which responded to the low power off. Next, the RF power transmitted from the base station is raised, and tags in a group which are further away than the first group respond, and are in turn communicated with and turned off. The process may be repeated until all tags in communication range of the base station with the maximum power allowed have finished the communication protocol.

Tags which themselves return different carrier frequencies than the base station carrier frequency are known in the art. A further embodiment of the invention is to select groups of such tags on the basis of the different measured carrier frequencies. The base station is programmed to receive the different tag carrier frequencies, either simultaneously or sequentially and to interrogate each group of tags. The different carrier frequencies known in the art are often the harmonics of the base station carrier frequency. However, the invention is not limited to the particular carrier frequency returned by the tags to the base station. If the tags can be selected into at least two groups, the communication protocol is speeded up.

FIG. **9** is a flow chart of a method of grouping the tags on the basis of the carrier frequency of the tags. The receiver is set to receive a carrier signal of frequency f_1 in step **910**. Step **920** instructs the tags to return signals. If a single tag is read in step **930**, the system instructs the tag in step **940** to turn off and return to step **920**. If no tag can be read in step **930**, the receiver frequency is changed in step **950** to f_2, and the tags are instructed in step **960** to return signals. If a single tag can be read in step **970**, the tag is communicated with and shut off in step **980**. If a single tag can not be read in step **970**, the multiple tag reading protocol is instituted. While two frequencies are used in this example, many more frequencies could also be used.

The carrier frequencies emitted by the tags and received by the base station may be apparently shifted from the base station carrier frequency by the Doppler shift due to the relative motion of the tags and the base station A further embodiment of the invention is to select groups of tags according to the Doppler shift of the carrier frequency sent by the tags and received by the base station. As an example, two groups of tags, those with relative motion of the tags towards the base station, and those with relative motion away from the base station, are selected for the communication protocol. This group selection is particularly valuable for a base station communicating with tags on one side of a doorway, for example, to measure whether the tags are carried into or out of a room.

Tags may return different modulation frequencies. A further embodiment of the invention is to select groups of tags on the basis of the modulation frequency of the returned tag signal. The base station is programmed to interrogate each group of tags either simultaneously or sequentially.

The invention is not limited to the above examples. The selection of groups of tags from a set of tags on the basis of any physically measured characteristics or attributes of the returned signal from the tags in response to any physical characteristic or attribute of the signal sent from the base station is well within the scope of the invention, as is the combination of the selection of groups on the basis of both physically measured characteristics and information contained on the tags.

We claim:

1. A method for communicating between a base station and a set of radio frequency RF transponders (Tags) comprising:

defining a plurality of RF tags into different groups according to a physical wave characteristic of the electromagnetic wave energy received from the RF tags, and

communicating with the tags in each defined group.

2. A method as in claim **1** wherein at least one defining wave characteristic is the wave amplitude.

3. The method of claim **1** wherein at least one defining physical wave characteristic is the wave frequency.

4. The method of claim **1** wherein at least one defining physical wave characteristic is the polarization of the signal.

5. The method of claim **1** wherein at least one defining physical wave characteristic is the phase shift of a return signal.

6. The method of claim **1** wherein at least one defining physical wave characteristic is the strength of tie signal.

7. The method of claim **1** wherein at least one defining physical wave characteristic is the amplitude modulation of the signal.

8. The method of claim **1** wherein at least one defining physical wave characteristic is the wavelength of the signal.

9. An RF tag base station comprising

a computer

a transmitter

a receiver, and

at least one antenna,

wherein the RF tag base station communicates with a plurality of RF tags by:

interrogating the RF tags with electromagnetic energy,

grouping the RF tags according to a physical characteristic of their responsive electromagnetic signals, and

reading the RF tags in each group.

10. A base station as in claim **9** wherein RF tags are grouped according to the wave amplitudes of their respective return signals.

11. A base station as in claim **9** wherein RF tags are grouped according to the wave frequency of their respective return signals.

12. A base station as in claim **9** wherein RF tags are grouped according to the polarization of their respective return signals.

13. A base station as in claim **9** wherein RF tags are grouped according to the phase shift of their respective return signals.

14. A base station as in claim **9** wherein RF tags are grouped according to the strength of their respective return signals.

15. A base station as in claim **9** wherein RF tags are grouped according to the amplitude modulation of their respective return signals.

16. A base station as in claim 9 wherein RF tags are grouped according to the frequency modulation of their respective return signals.

17. A base station as in claim 9 wherein RF tags are grouped according to the wavelength of their respective return signals.

18. An RF tag unit reading unit comprising:

a computer;

a transmitter;

a receiver; and

at least one antenna;

wherein the RF tag reading unit communicates with a plurality of RF tags by:

interrogating the RF tags with electromagnetic energy;

grouping the RF tags according to a physical characteristic of their responsive electromagnetic signals, and

reading the RF tags in each group.

* * * * *

EXHIBIT D

US006371375B1

(12) **United States Patent**
Ackley et al.

(10) **Patent No.: US 6,371,375 B1**
(45) **Date of Patent: Apr. 16, 2002**

(54) **METHOD AND APPARATUS FOR ASSOCIATING DATA WITH A WIRELESS MEMORY DEVICE**

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(73) Assignee: **Intermec IP Corp.**, Beverly Hills, CA (US)

(21) Appl. No.: **09/249,359**

(22) Filed: **Feb. 12, 1999**

Related U.S. Application Data

(63) Continuation-in-part of application No. 09/064,886, filed on Apr. 20, 1998, now Pat. No. 6,056,199, which is a continuation-in-part of application No. 08/978,608, filed on Nov. 26, 1997, now abandoned, which is a continuation of application No. 08/533,568, filed on Sep. 25, 1995, now abandoned, application No. 09/249,359, which is a continuation-in-part of application No. 09/021,608, filed on Feb. 10, 1998.

(51) **Int. Cl.**[7] **G06K 7/10**
(52) **U.S. Cl.** **235/462.45**; 235/462.46
(58) **Field of Search** 235/462.45, 462.46

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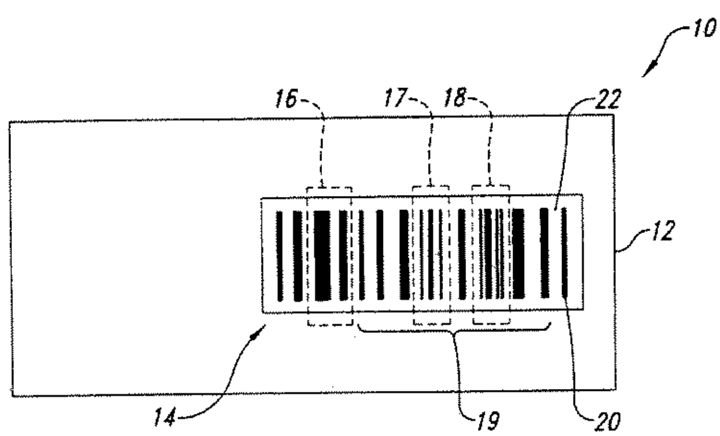
Primary Examiner—Harold I. Pitts
(74) *Attorney, Agent, or Firm*—Seed IP Law Group, PLLC

(57) **ABSTRACT**

A system for storing and retrieving data comprises a memory device, such as a radio frequency tag, having a memory for storing the data, a first identifier stored in the memory, and a machine-readable symbol associated with the memory device. At least a portion of the machine-readable symbol encodes a second identifier logically associable with the first identifier. The machine-readable symbol may be printed on an RF tag, or may be carried by a container that also carries an RF tag. The machine-readable symbol is composed of characters from a machine-readable symbology, and includes a flag character that indicates the existence of a memory device corresponding to the machine-readable symbol. A reader for reading the machine-readable symbol and the memory device conserves power by determining from the flag character whether a memory device is associated with the symbol, prior to operating a memory device reader section of the reader. The reader reads the machine-readable symbol to obtain a symbol identifier, and successively reads each of a number of memory devices to obtain a memory device identifier until a memory device identifier corresponding to the symbol identifier is found. Alternatively, the reader may successively read each of the number of memory devices to obtain each of the memory device identifiers, read the machine-readable symbol to obtain a symbol identifier, and match the symbol identifier to one of the memory device identifiers.

6 Claims, 9 Drawing Sheets



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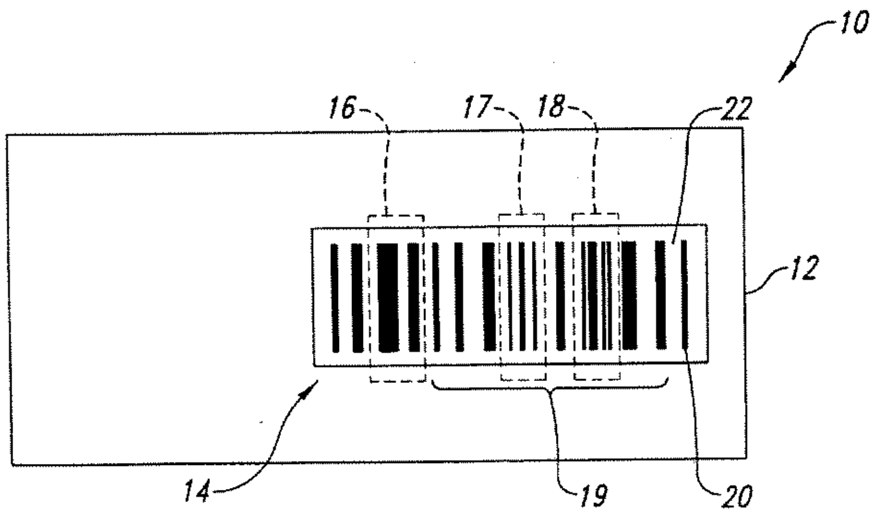


Fig. 1

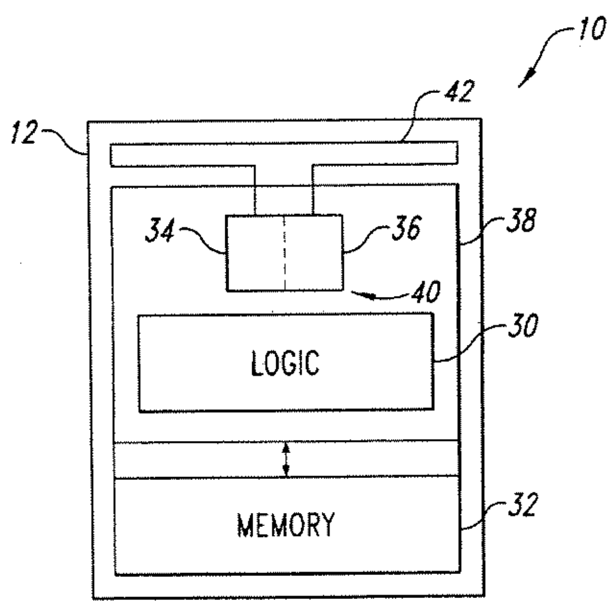
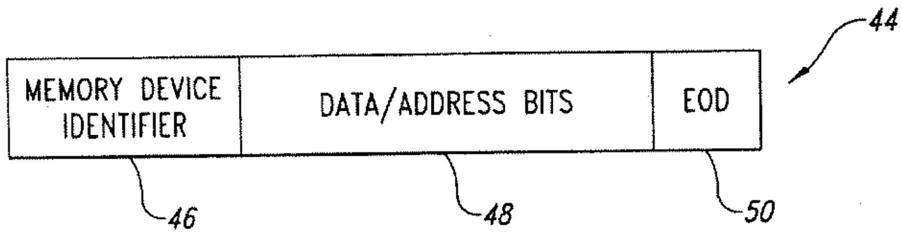


Fig. 2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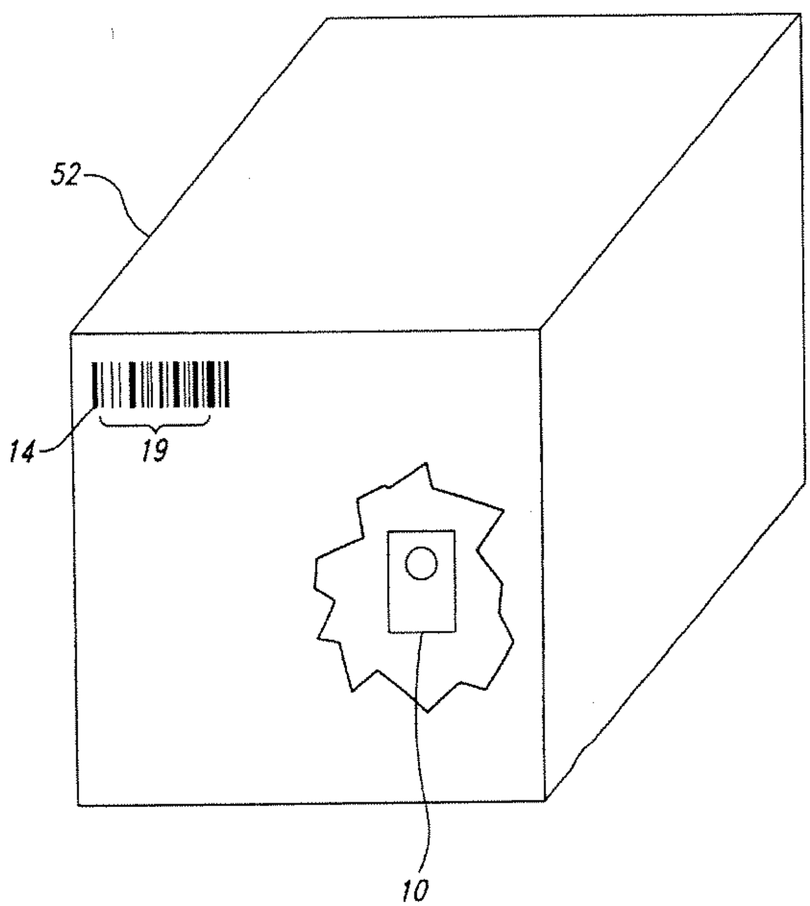
DATA/ADDRESS BITS
EOD
46
48
50

Fig. 3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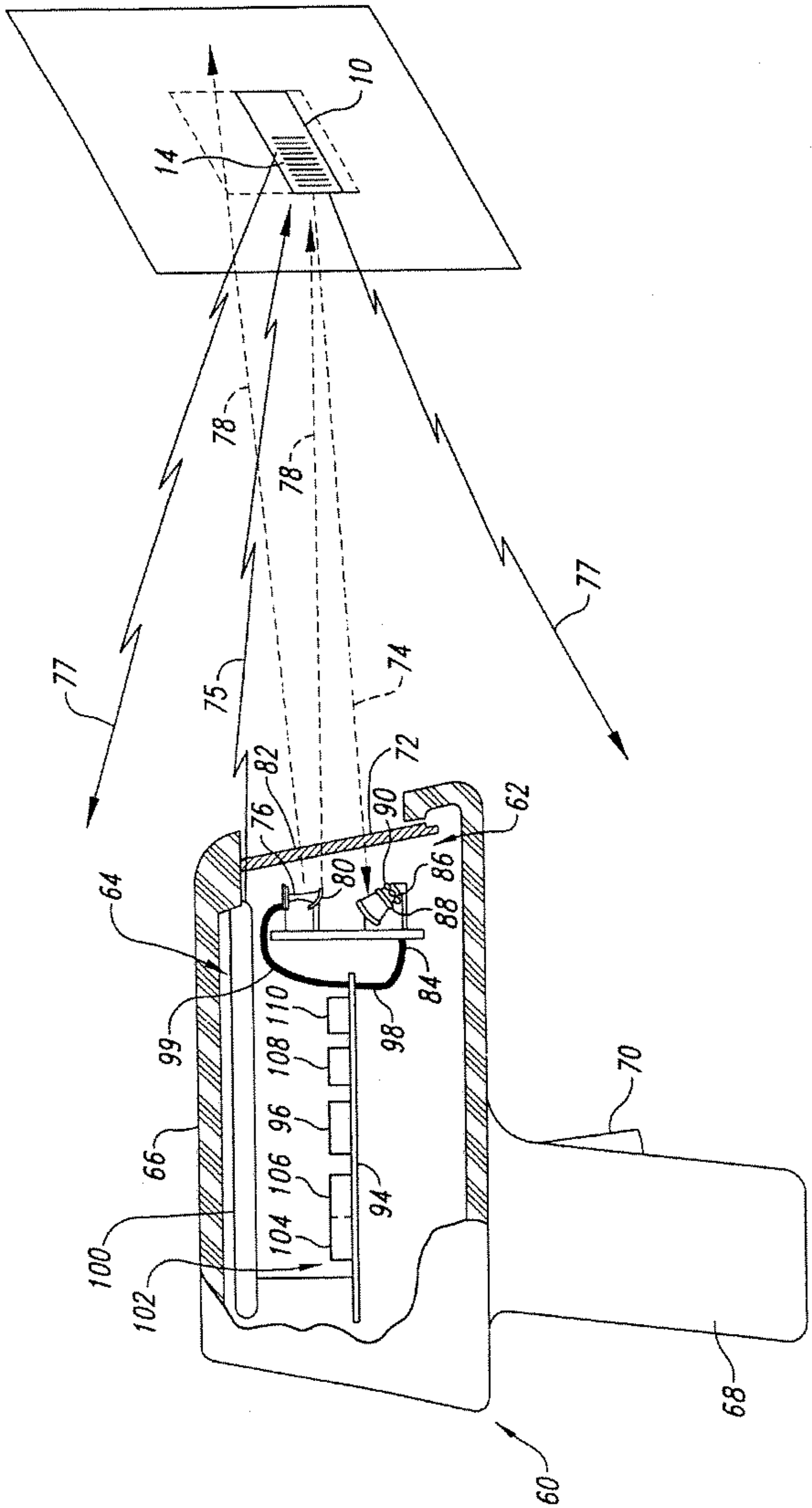
14
19
10

Fig. 4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60

Fig. 5

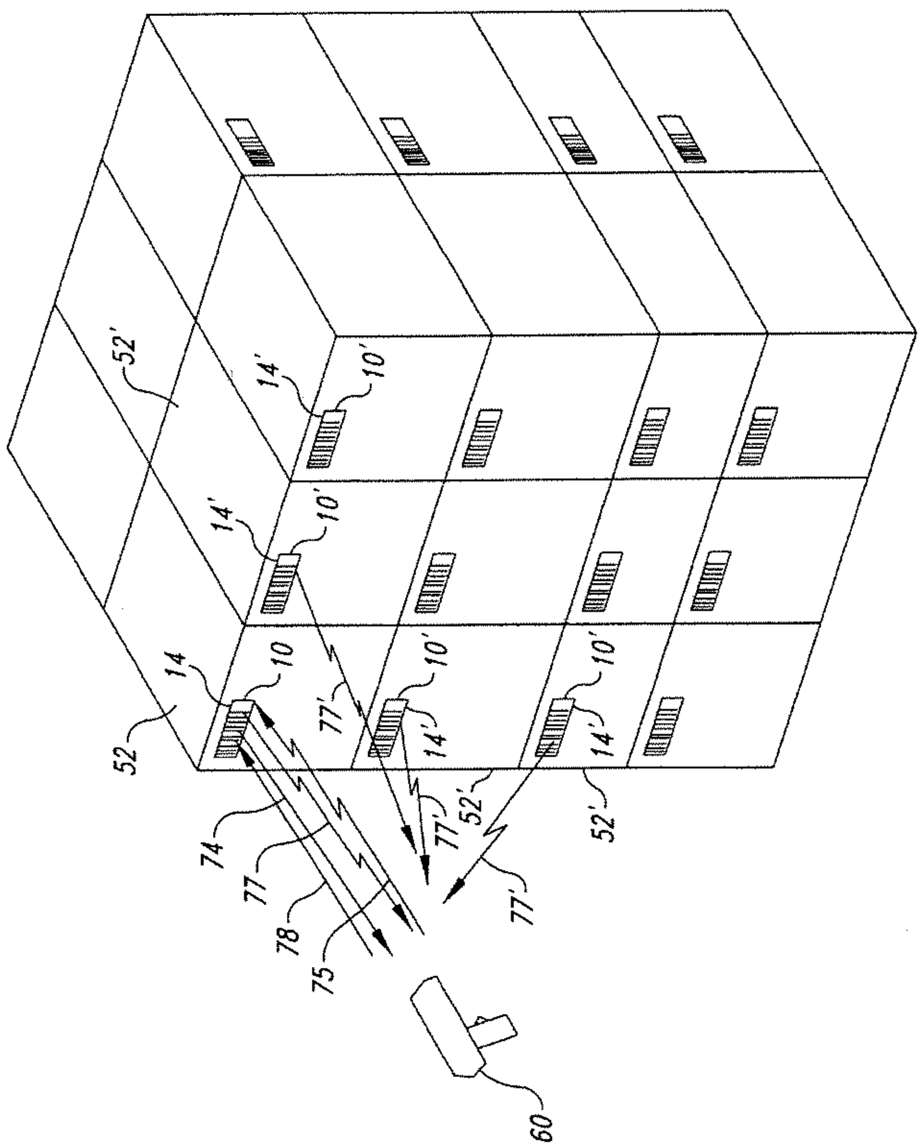
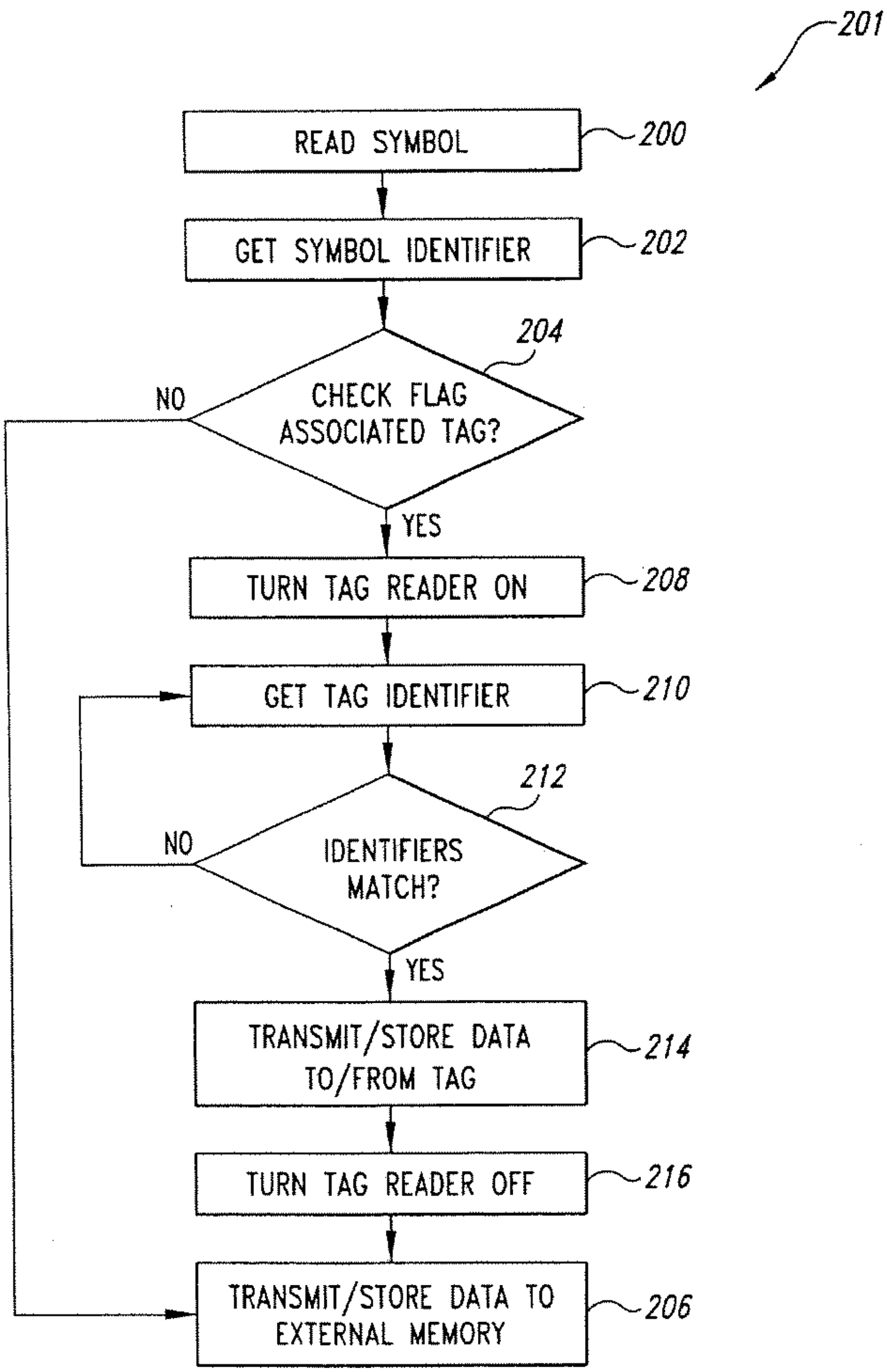


Fig. 6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READ SYMBOL
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GET SYMBOL IDENTIFIER
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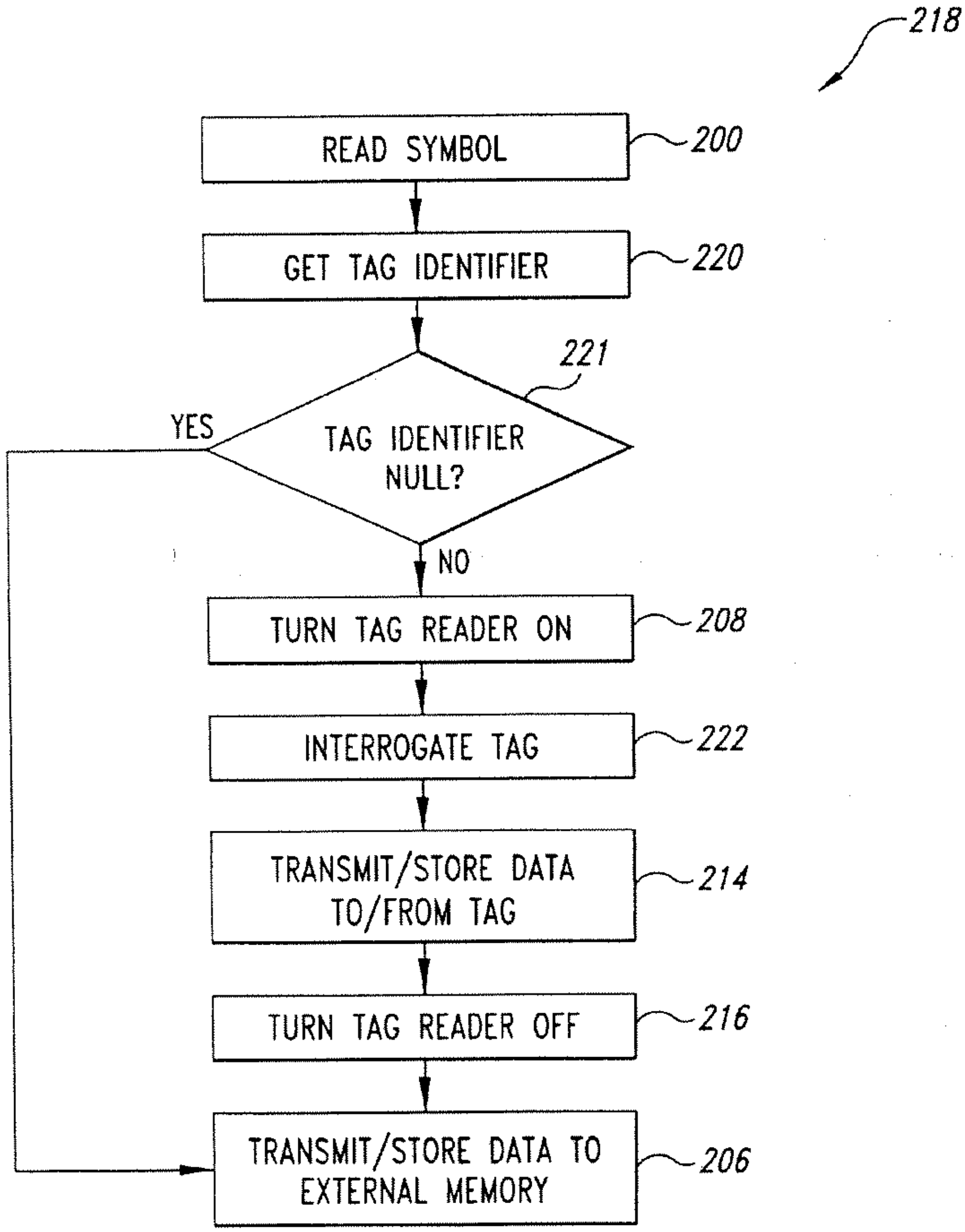
204
CHECK FLAG ASSOCIATED TAG?
NO
YES
TURN TAG READER ON
208
GET TAG IDENTIFIER
210
212
IDENTIFIERS MATCH?
NO
YES
TRANSMIT/STORE DATA TO/FROM TAG
214
TURN TAG READER OFF
216
TRANSMIT/STORE DATA TO EXTERNAL MEMORY
206

Fig. 7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READ SYMBOL
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GET TAG IDENTIFIER
220
221
TAG IDENTIFIER NULL?
YES
NO
TURN TAG READER ON
208
INTERROGATE TAG
222
TRANSMIT/STORE DATA TO/FROM TAG
214
TURN TAG READER OFF
216
TRANSMIT/STORE DATA TO EXTERNAL MEMORY
206

Fig. 8

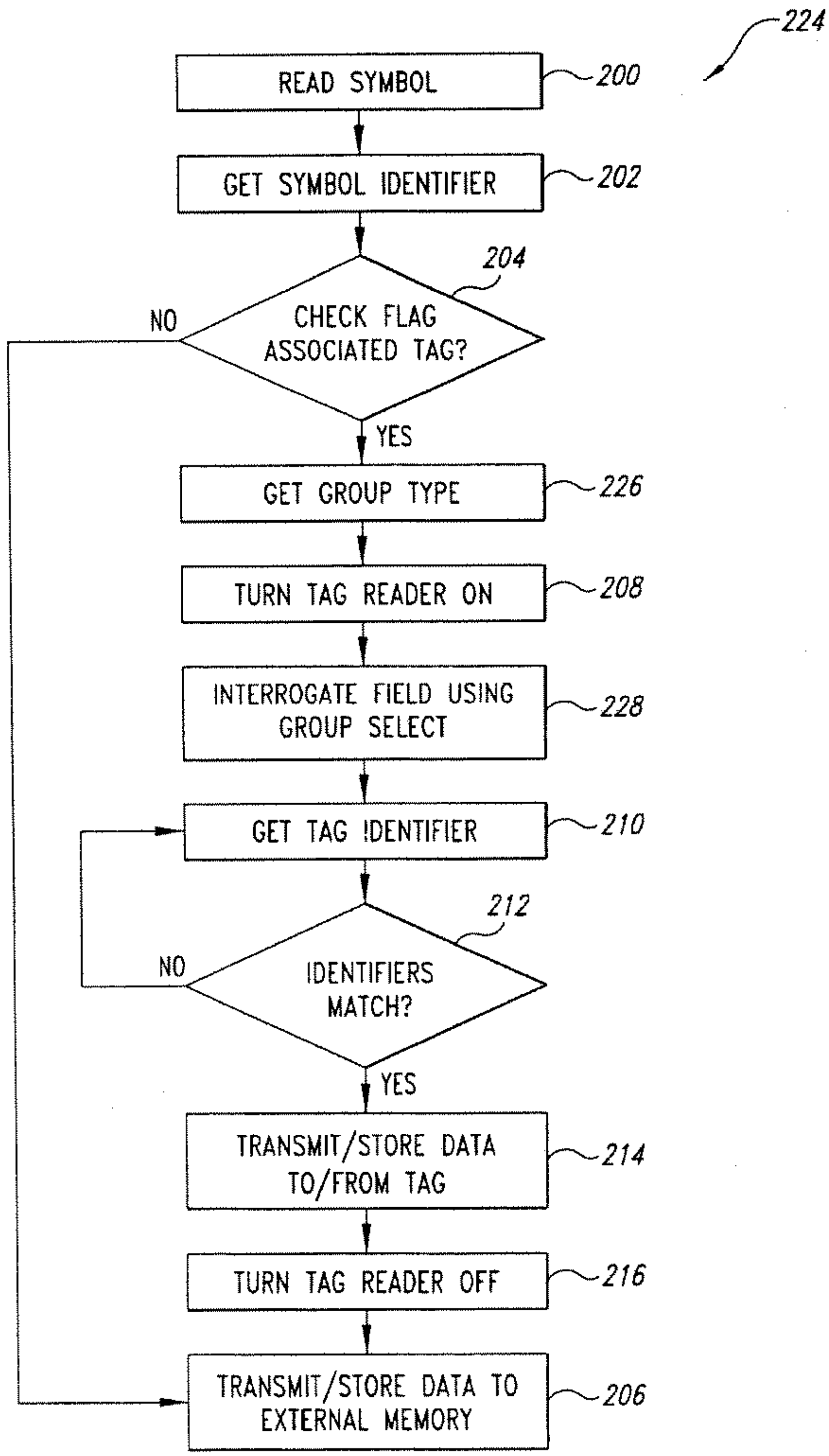
224
READ SYMBOL
200
GET SYMBOL IDENTIFIER
202
204
CHECK FLAG ASSOCIATED TAG?
NO
YES
GET GROUP TYPE
226
TURN TAG READER ON
208
INTERROGATE FIELD USING GROUP SELECT
228
GET TAG IDENTIFIER
210
212
IDENTIFIERS MATCH?
NO
YES
TRANSMIT/STORE DATA TO/FROM TAG
214
TURN TAG READER OFF
216
TRANSMIT/STORE DATA TO EXTERNAL MEMORY
206

Fig. 9

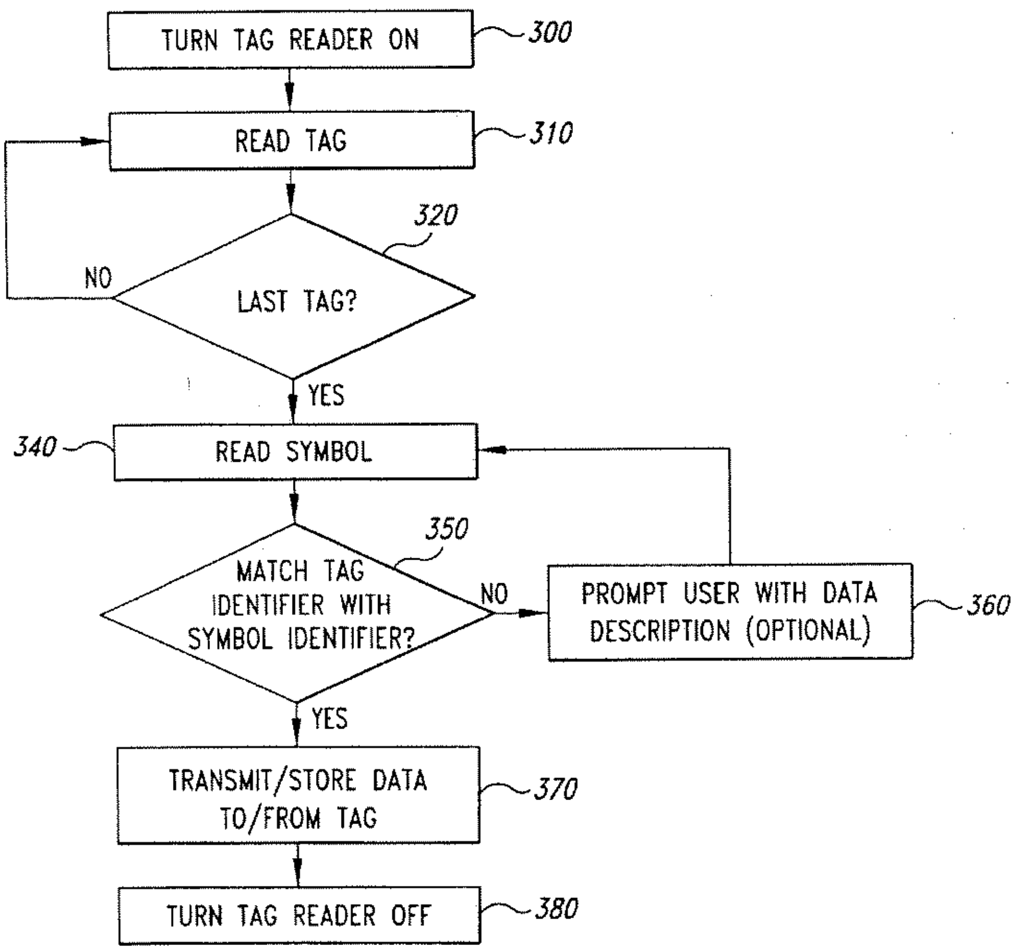
TURN TAG READER ON
300
READ TAG
310
320
NO
LAST TAG?
YES
340
READ SYMBOL
350
MATCH TAG IDENTIFIER WITH SYMBOL IDENTIFIER?
NO
PROMPT USER WITH DATA DESCRIPTION (OPTIONAL)
360
YES
TRANSMIT/STORE DATA TO/FROM TAG
370
TURN TAG READER OFF
380

Fig. 10

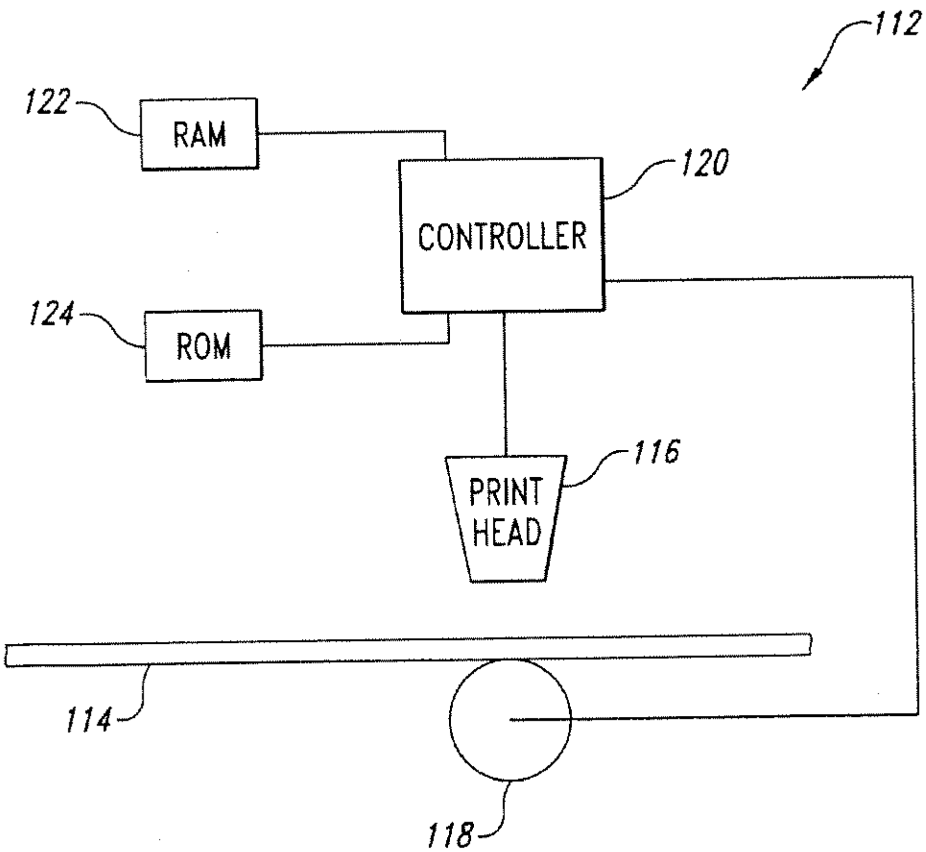

Fig. 11

METHOD AND APPARATUS FOR ASSOCIATING DATA WITH A WIRELESS MEMORY DEVICE

CROSS-REFERENCES TO RELATED APPLICATIONS

This application is a continuation-in-part of U.S. patent application Ser. No. 09/064,886, filed Apr. 20, 1998, now U.S. Pat. No. 6,056,199, which is a continuation-in-part of U.S. patent application Ser. No. 08/978,608, filed Nov. 26, 1997, now abandoned, which is a continuation of U.S. patent application Ser. No. 08/533,568, filed Sep. 25, 1995, now abandoned. This application is also a continuation-in-part of U.S. patent application Ser. No. 09/021,608, filed Feb. 10, 1998, currently pending.

TECHNICAL FIELD

The present invention relates to readable and/or writable memory devices, such as radio frequency memory tags.

BACKGROUND OF THE INVENTION

A variety of methods exist for tracking and providing information about items. For example, inventory items in stores typically bear printed labels providing information such as serial numbers, price, weight, and size. Some labels include machine-readable symbols, such as bar code symbols, which may be selected from a variety of symbologies. These labels contain a limited amount of information due to space constraints. Updating the information on these labels typically requires the printing of a new label to replace the old label.

Memory devices such as radio frequency ("RF") tags provide an alternative method of tracking and providing information about items. Memory devices permit large amounts of data to be associated with an object or item. Memory devices typically include a memory and logic in the form of an integrated circuit ("IC") and means for transmitting data to and from the memory. For example, an RF tag typically includes a memory, an RF transmitting section, an RF receiving section, an antenna, and logic for controlling the memory, the RF transmitting section and the RF receiving section. RF tags are generally formed on a substrate and may include, for example, analog RF circuits and digital logic and memory circuits. The RF tags may also include a number of discrete components, such as capacitors and diodes where such is advantageous.

The RF tags may be either passive or active devices. Active devices are self-powered, by a battery, for example. Passive devices do not contain a power source, but derive their energy from the RF signal used to interrogate the RF tag. Passive RF tags usually include an analog circuit which detects and decodes the interrogating RF signal and which provides power from the RF field to a digital circuit in the tag. The digital circuit generally executes all of the functions performed by the RF tag, such as retrieving stored data from memory and modulating the RF signal to transmit the retrieved data. In addition to retrieving and transmitting data previously stored in the memory, the RF tag may permit new or additional information to be stored into the RF tag's memory or may permit the RF tag to manipulate data or perform some additional functions.

A significant drawback of memory devices such as RF tags is the inability to associate a specific memory device, or item to which it is attached, with a given data signal. For example, where a number of longer range RF tags (e.g., range greater than approximately 6 inches) are in relatively close proximity to one another, a reader will receive data from all of the RF tags in either a defined sequence or a random sequence. However, the reader is unable to associate the received data with any particular RF tag. So, while a user may determine that a particular item is present among a number of items or containers, the user is unable to specifically identify which one of the items or containers the data describes.

Attempts have been made to overcome this problem. For example, one cost-effective means of associating data with a particular item is to physically move each item out of range of the reader until the desired item is identified. Another attempt includes the use of triangulation. However triangulation has accuracy limitations and requires multiple pieces of equipment or multiple sampling of data at different locations.

SUMMARY OF THE INVENTION

In one aspect of the invention, a system for storing and retrieving data comprises a memory device such as a radio frequency tag having a memory for storing the data, a first identifier stored in the memory of the memory device, and a machine-readable symbol associated with the memory device, where at least a portion of the machine-readable symbol encodes a second identifier logically associable with the first identifier. The machine-readable symbol may, for example, be printed on the memory device, or may be carried by a container that also carries the memory device. The data stored in the memory device may include data related to the container or items carried by the container.

In another aspect of the invention, at least a portion of a machine-readable symbol includes a flag, the flag being logically associated with the existence of a memory device such as an RF tag corresponding to the machine-readable symbol. The flag is set to a first value when an RF tag corresponding to the machine-readable symbol exists, and to a second value when an RF tag does not exist. Thus, a reader reading the machine-readable symbol is able to determine whether an RF tag exists and may control an RF portion of the reader appropriately.

Similarly, in another aspect of the invention, a machine-readable symbology includes a number of symbol characters, including a flag character that indicates that at least one memory device corresponding to the machine-readable symbol exists.

In another aspect of the invention, a method of conserving power in a reader includes operating a symbol reading portion of the reader to read a symbol, determining whether a memory device is associated with the symbol from the data encoded in the read symbol, and operating a memory device reader portion of the reader if a memory device is associated with the symbol.

In yet another aspect of the invention, a method of associating a machine-readable symbol with data stored in one of a number of memory devices includes reading the machine-readable symbol to obtain a symbol identifier, and successively reading each of a number of memory devices to obtain a memory device identifier and comparing the memory device identifier and the symbol identifier, until a memory device is read that has a memory device identifier that corresponds to the symbol identifier.

In a further aspect of the invention, a method of associating a machine-readable symbol with data stored in one of a number of memory devices includes successively reading each of the number of memory devices to obtain a memory

device identifier for each of the number of memory devices, reading the machine-readable symbol to obtain a symbol identifier, and matching the symbol identifier to the memory device identifier of one of the number of memory devices.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a top plan view of an RF tag incorporating a machine-readable symbol and an RF readable and writable memory device.

FIG. 2 is a block diagram of the RF tag of FIG. 1.

FIG. 3 is a data structure for data transmitted according to the protocol of the RF tag.

FIG. 4 is an isometric, partially broken view of a container carrying a machine-readable symbol and an RF tag.

FIG. 5 is a side cross-sectional view of a reader including a symbol reader portion and a memory device reader portion.

FIG. 6 is a perspective view of a number of containers carrying machine-readable symbols and RF tags.

FIG. 7 is a flowchart showing the steps for associating data with a particular memory device according to a first embodiment, where a tag identifier encoded in an RF tag is matched to a tag identifier encoded in a machine readable symbol.

FIG. 8 is a flowchart showing the steps for associating data with a particular memory device using an alternative tag addressing schema, where a tag identifier encoded in a machine readable symbol is used to interrogate a specific RF tag.

FIG. 9 is a flow chart showing the steps for associating data with a particular memory device using another alternative addressing schema, where a group of RF tags are interrogated.

FIG. 10 is a flowchart showing the steps for associating data with a particular memory device according to a second exemplary embodiment where a number of RF tags are read and matched to a tag identifier encoded in a machine readable symbol.

FIG. 11 is a block diagram of a printer for printing a machine-readable symbol according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

In the following description, certain specific details are set forth in order to provide a thorough understanding of various embodiments of the invention. However, one skilled in the art will understand that the invention may be practiced without these details. In other instances, well-known structures associated with memory devices, integrated circuits, radio frequency communications, symbologies, and readers have not been shown in detail to avoid unnecessarily obscuring the description of the embodiments of the invention.

FIG. 1 shows a memory device in the form of a radio frequency ("RF") tag 10 formed as a substrate 12. The substrate 12 is adapted for repeatable attachment and detachment to various objects using known attachment means, such as hook and loop fastener commonly available as Velcro®, so that the RF tags 10 are reusable. Alternatively, the RF tag 10 can be a single use device, including a pressure sensitive adhesive and release liner (not shown) on the substrate 12.

A machine-readable symbol, such as the bar code symbol 14, is carried by the substrate 12, such that the bar code

symbol 14 is perceptually associable with the RF tag 10. Any conventional means for placing the bar code symbol 14 on the substrate 12 may be employed, such as printing or silk screening directly onto the substrate 12. Alternatively, the bar code symbol 14 may be printed on a label and the label applied to the substrate 12 or attached in some other fashion.

The bar code symbol 14 is a pattern of regions of varying reflectance on an exposed portion of the substrate 12 that reflects some of the light from an illumination source. The bar code symbol 14 includes a number of characters, three of which are identified by the broken line boxes 16, 17, 18 in FIG. 1. Each character is composed of a number of lines 20 and spaces 22 of varying widths. The characters 16–18 are selected from a set of characters known as a symbology. Numerous symbologies are known and may include bar code symbologies such as UPC, EAN, Code 39, and Code 93i; "multi-row" or "stacked" symbologies such as PDF-417 and Code 49; and "area" symbologies such as Code One. The bar code symbol 14 represents a bar code symbol composed of characters selected from the Code 93i symbology. The characters of the bar code symbol 14 encode data including a symbol identifier 19.

One of the characters 16 in the bar code symbol 14 may indicate the existence of a companion data carrier (e.g., a memory device such as an RF tag). For example, a version of Code 93i proposed in U.S. patent application Ser. No. 09/021,608, filed Feb. 10, 1998, describes the use of such a flag character. The flag character 16 indicates the existence of an RF tag 10 when positioned in the first position following the start character. One or more character values following the initial flag character in the first position are either "modifier" characters that identify adjacent tag indication values and that provide specific reader instructions to assist in the decode and data management of the RF tag 10. Alternatively, the flag character 16 may be placed in the last position before the check or error correction characters. Companion data carriers typically encode supplementary data related to the 93i symbol to which it is a companion. When a reader scans or images a 93i symbol having the 93i start and stop characters, or a symbol having other 93i start/stop characters with the appropriate flag character, the reader understands that an associated RF tag 10 exists and therefore attempts to collect data from the RF tag 10.

FIG. 2 shows the passive RF memory tag 10 as a block diagram. The RF tag 10 includes a memory 32, an RF detector 34, and an RF emitter 36, all coupled by a logic 30. The RF detector 34 and the RF emitter 36 may be integrally formed in an integrated circuit 38 as an RF transceiver 40, sharing a common antenna 42. Alternatively, the RF detector 34 may be an RF receiver coupled to the antenna 42, while the RF emitter 36 may be an RF transmitter coupled to a separate antenna (not shown).

The integrated circuit 38 may include an analog circuit comprising the RF transceiver 40, and a digital circuit comprising the logic 30 and the memory 32. The logic 30 may take the form of microcode, a hardwired circuit or a combination of microcode and a hardwired circuit. The RF detector 34 converts an RF signal from the antenna 42 to a DC voltage that powers up the logic 30 and transmits information and commands for storing and retrieving data from the memory 32. The digital circuit generally executes all of the functions of the RF memory tag 10, such as retrieving stored data from the memory 32 and modulating the RF signal to transmit the retrieved data. The substrate 12 serves as a protective housing, enclosing the various components. While the RF tag 10 shown is a passive device, a self-powered active device may be successfully employed.

The logic **30**, in the form of a microprocessor or microcontroller, controls data transfer and electrical operation of the RF tag **10** in a manner known in the art using a manufacturer-identified protocol.

FIG. 3 shows a simple data structure **44** for the memory **32**. The data structure **44** includes a memory device identifier **46**, data or address bits **48**, and an end of data field indicator **50**. The memory device identifier **46** contains a unique identifier for the specific RF tag **10**. The data or address bits **48** contain data relating to an object or item associated with the RF tag **10**. The end of data field indicator **50** indicates the end of data.

While FIG. 1 shows the bar code **14** carried by the substrate **12**, there are other ways of perceptually linking or associating the bar code symbol **14** and the RF tag **10**. For example, in FIG. **4**, a container **52** carries the bar code symbol **14** on a visible surface of the container **52**. The RF tag **10** is enclosed within the container **52**, or may be carried on a visible or non-visible surface of the container **52**. The container **52** may also contain one or a number of various items (not shown). Data relating to the items located in the container **52** may be stored in the memory **32** of the RF tag **10**. The RF tag **10** also stores a memory device identifier **46** (FIG. 3). At least a portion of the bar code symbol **14** encodes characters representing a symbol identifier 19 (FIG. 1). The symbol identifier 19 is logically associable to the memory device identifier **46**.

The symbol identifier **19** may take the form of a multi-character alphanumeric identifier. The memory device identifier **46** may also take the form of a multi-character alphanumeric identifier and may be identical to the symbol identifier **19**. Alternatively, the symbol identifier **19** and, or the memory device identifier **46** may be an address that points to a memory location containing a unique identifier. Additional ways of linking or associating the symbol identifier **19** and the memory device identifier **46** are within the scope of the invention, as those skilled in the relevant art will appreciate.

FIG. **5** shows a reader **60** for reading an RF tag **10** including the ability to read other machine-readable symbols such as the bar code symbol **14**. The reader **60** includes a head **66**, a handle **68**, and a trigger **70** for activating the reader **60**. The reader **60** further includes a symbol reader section **62** for reading the bar code symbol **14** and an RF reading section **64** for transmitting data to and from the memory **32** of the RF tag **10**.

With respect to the symbol reader section **62**, the head **66** includes a window **72** for receiving light reflected from the bar code symbol **14**, shown as broken-line arrow **74**. The bar code symbol **14** may reflect ambient light or may reflect an illuminating beam that the reader produces with one or more laser diodes **76**, the illuminating beam shown as broken-line arrows **78**. The illuminating beam **78** is directed out of the reader **60**, for example, with the assistance of a mirror **80** and lens **82**. The reader **60** may produce the illuminating beam **78** as a scanning beam by employing a scanning motor (not shown) to pivot the mirror **80** through a selected angular range such that when the light from the laser diode **76** strikes the mirror **80**, the light is swept through a corresponding angular range, thus forming the scanning beam. The structure and operation of such a combination is well known in the art. Alternatively, the reader **60** may employ a fixed illumination beam **78** and electronic means for scanning the reflected beam **74**. Electronic means for scanning the reflected beam **74** are also well known in the art.

The symbol reader section **62** may further include a gathering mirror **84** that gathers the reflected light **79** and directs it toward a photodetector **86** through a lens **88**. To reduce the sensitivity of the photodetector **86** to ambient light, a wavelength selective optical filter **90** may be placed between the lens **88** and the photodetector **86**. The photodetector **86** may take the form of a linear array of photosensitive elements, preferably a charged coupled device ("CCD") having, for example, linear active surface pixel elements. While the depicted embodiment of the symbol reader section **62** is of a laser scanner, the symbol reader section **62** can employ other known reading systems and imagers, such as Vidicons, two-dimensional semiconductor arrays, or a two-dimensional CCD array. Additionally, other sized CCD arrays may be used, for example, circular or square CCD arrays.

Furthermore, while the exemplary embodiment of the photodetector **86** is of a linear imager, those skilled in the relevant art will readily recognize that other image digitizing or capturing devices can be employed, including color sensitive devices. The reader **60** may employ electronic means to selectively sample each pixel element of the photodetector **86** to effectively scan the bar code symbol **14**. This eliminates the need for a scanning illumination beam, and the equipment to produce such a scanning illumination beam. Thus, the symbol reader section **62** may be significantly simplified by reducing the number of moving parts.

The photodetector **86** converts the reflected light into an electrical signal and couples the electrical signal by way of electrical lead **98** to a printed circuit board **94** carrying a microprocessor **96**. The microprocessor **96** receives the electrical signal from the photodetector **86** and decodes the electrical signal to identify the information represented by the bar code symbol **14**. The microprocessor **96** also controls the laser diode **76** via a lead **99**.

The RF section **64** of the reader **60** includes an antenna **100** coupled to a transceiver **102** that includes a transmitter **104** and a receiver **106**. The transmitter **104** is capable of producing RF interrogation signals, shown as zigzag lines **75**, to interrogate and transmit data to the RF tag **10**. The receiver **106** is capable of receiving RF data signals **77** from the RF tag **10**. One skilled in the art will note that the transmitter **104** and receiver **106** may be formed as separate components, each coupled with a respective antenna.

The microprocessor **96** is coupled to the transceiver **102** for controlling the operation of the transmitter **104** and the receiver **106**. A memory, such as a read-only memory ("ROM") **108**, is coupled to the microprocessor **96** for storing programs and data for the microprocessor **96** to execute. Another memory, such as a random access memory ("RAM") **110**, is also coupled to the microprocessor **96** for providing storage for data received by the receiver **106** and decoded by the microprocessor **96**. Power for these components may be supplied via a power bus (not shown), from an external power supply, or from an internal power supply, such as one or more batteries (not shown).

FIG. 6 shows a number of containers **52, 52'** in close proximity to each other. Each of the containers **52, 52'** has a bar code symbol **14, 14'** on an exposed surface of the container. While in the embodiment shown, the bar code symbols **14, 14'** are carried on the substrate of the RF tags **10, 10'**, the bar code symbols **14, 14'** may be printed directly onto the containers **52, 52'** or applied to the containers **52, 52'** as labels. Data pertaining to the containers **52, 52'** or the contents of the containers **52, 52'** may be encoded in each of the respective RF tags **10, 10'**.

Due to the close proximity of the RF tags **10, 10'** to one another, the reader **60** will receive data signals **77, 77'** from

a selected carton **52** and neighboring cartons **52'**, respectively. The reader **60** may employ a discrimination or arbitration scheme as is generally known in the art to prevent the data signals **77, 77'** from interfering with one another. For example, the reader **60** may include information in the interrogation signal **75** to randomize the response of the RF tags **10, 10'** by introducing a different time delay in the response of each of the RF tags **10, 10'**.

The reader **60** generates an illumination beam **78** to scan the bar code symbol **14** of the selected container **52**. The reader **60** receives the beam **74** reflected from the bar code symbol **14** on the selected container **52**.

A first exemplary method of associating data with a particular RF tag **10** will be discussed with reference to FIGS. **6** and **7**. In step **200** of routine **201**, when a user desires information or data regarding a selected container **52** or the contents of the selected container **52**, the user activates the reader **60** to read the bar code symbol **14** on the selected container **52**. The reader **60** illuminates the bar code symbol **14** with an illumination beam **78** and receives the reflected light **74**. In step **202**, the reader **60** decodes the data encoded in the bar code symbol **14** to obtain a symbol identifier **19** (FIG. **1**).

In step **204**, the reader **60** checks a flag character **16** in the bar code symbol **14** (FIG. **1**) to determine whether an RF tag **10** is associated with the bar code symbol **14**. If no RF tag **10** is associated with the bar code symbol **14**, the reader **60** transmits or stores data, for example, by storing data to an external memory (not shown), in step **206**. To conserve power, the reader **60** may keep the RF section **64** in an OFF state if no RF tag **10** is associated with the bar code symbol **14**. If an RF tag **10** is associated with the bar code symbol **14** in step **208**, the reader **60** places the RF section **64** of the reader **60** into an ON state, supplying power to the RF section **64**. In step **210**, the reader **60** transmits the RF interrogation signal **75**, receives an RF data signal **77** in response to the RF interrogation signal **75** and decodes the RF data signal **77** to obtain a memory device identifier **46** (FIG. **3**).

Also to conserve power, the RF section **64** may initially transmit the RF interrogation signal **75** at a first relatively low power level. The RF section **64** may then transmit the RF interrogation signal **75** at a second relatively higher power level if no RF data signal **77** is returned from the RF tag **10**.

In step **212**, the reader **60** compares the memory device identifier **46** (FIG. **3**) with the symbol identifier **19** to determine whether the RF data signal **77** corresponds with the scanned bar code symbol **14**. The reader **60** successively receives and decodes the RF data signals **77, 77'** until a match is found and may provide tactile feedback to the user in an audible, visual or other form when a match is found. For example, the reader **60** may produce a particular tone, or tone pattern when a match is found. Alternatively, or additionally, the reader **60** may flash a light such as an LED (not shown) when a match is found.

Once the reader **60** has linked or associated the appropriate RF data signal **77** with the scanned bar code symbol **14**, the reader **60** may, in step **214**, receive or transmit data either to or from the particular RF tag **10**. In step **216**, the reader **60** places the RF section **64** into an OFF state, discontinuing or reducing the power supply to the RF section **64**. This permits the reader **60** to conserve power while it is not actively receiving RF data signals **77, 77'** or transmitting RF interrogation signal **75**.

As shown in FIG. **8**, an alternative embodiment under the present invention employs a routine **218** that includes steps that are similar to routine **201** of FIG. **7**. This alternative embodiment, and those described herein, are substantially similar to previously described embodiments, and common steps are identified by the same reference numbers. Only the significant differences in operation are described in detail.

In routine **218**, the reader **60** reads the bar code symbol **14** in step **200**, retrieves the tag identifier **46** in step **220** for any associated RF tag **10**. In step **221**, if the tag identifier **46** is null or some other pre-defined value, the data encoded in the bar code symbol **14** is transmitted to an external memory in step **206**. If the tag identifier **46** is not null, then the RF section **64** of the reader **60** is turned ON in step **208** and performs an addressed interrogation in step **222**. The addressed interrogation employs the tag identifier **46** to address only the specific RF tag **10** that the tag identifier **46** identifies.

Another alternative exemplary method is shown in FIG. **9**. In FIG. **9**, the reader **10** performs routine **224**, reading the bar code symbol **14** (Step **200**), retrieving the symbol identifier **19** (Step **202**) from the read data and checking for associated RF tags **10** (Step **204**). In step **226**, the reader **10** also retrieves a group type from the read data, that identifies a group of related RF tags **10**. For example, a bar code symbol **14** on the outside of a container **52** (FIG. **4**) may encode a group type that is common to all RF tags **10** within the container **52**, each item in the container **52** having an RF tag **10** physically associated therewith. Thus the group type corresponds to a particular container **52** and all items within the container **52**. One skilled in the art will note that the group type does not need to be expressly encoded in the bar code symbol **14**, and may be inferred from other encoded data such as the symbol identifier **19**.

In step **208**, the RF section **64** of the reader **10** is turned ON and in step **228** the RF section **64** interrogates all RF tags **10** within its range using the group type retrieved from the bar code symbol **14**. A suitable method for performing a group select interrogation is disclosed in U.S. Pat. No. 5,673,037. In steps **210** and **212**, the individual responses from the RF tags **10** may be sorted using the symbol identifier **19** and tag identifiers **46** in a fashion similar to that shown in FIG. **7**.

A further exemplary method of associating data with an RF tag **10** will be discussed with reference to FIGS. **6** and **10**. In step **300**, the user places the RF section **64** of the reader **60** into an ON state. In steps **310** and **320**, the reader **60** successively reads each of the RF tags **10, 10'** by transmitting the RF interrogation signal **75** and receiving each of the RF data signals **77, 77'**. In step **340**, the user reads the bar code symbol **14** carried by a selected container **52**. In step **350**, the reader **60** attempts to match the symbol identifier **19** (FIG. **1**) encoded in the bar code symbol **14** with the memory device identifier **46** (FIG. **3**) encoded in the RF data signals **77, 77'**. In optional step **360**, the reader **60** prompts the user, for example, with a description of the data stored in the bar code symbol **14** if no match is found, and the reader **60** returns to reading bar code symbols **14, 14'** (step **340**). If a match is found, the reader **60** transmits and, or stores data to and, or from the RF tag **14**, in step **370**. In step **380**, the RF section **64** of the reader **60** is placed into an OFF state, thereby conserving power.

FIG. **11** shows a printer **112** for printing on a print medium **114**. The print medium may be an RF tag **10** (FIG. **1**), or may be a label or other substrate. The printer **112** includes a print head **116** for printing on the print medium **114** and may include a platen **118** for supporting and advancing the print medium **114** relative to the print head **116** for printing. The

print head **116** may be a thermal print head, ink jet print head, laser print head or other conventional print head. The printer **112** further includes a controller **120** coupled to the print head **116** and the platen **118** for controlling and synchronizing the operation of the print head **116** and the platen **118**. The controller **120** may further couple to a first memory, such as the RAM **122**, and a second memory, such as the ROM **124**, to retrieve and store data and instructions as is commonly known by those skilled in the art. The first or second memory **122**, **124** may store instructions or printing a machine readable symbol, including at least one flag character **16** (FIG. **1**) that indicate the existence of an associated RF tag **10** (FIG. **1**).

Although specific embodiments of, and examples for, the present invention are described herein for illustrative purposes, various equivalent modifications can be made without departing from the spirit and scope of the invention, as will be recognized by those skilled in the relevant art. One skilled in the art will recognize that the teaching herein perceptually relates data to a memory device, as well as perceptually relating the data to an item or a container containing an item or group of items. The teachings provided herein of the present invention can be applied to reading other memory devices not necessarily the radio frequency tags generally described above. For example, the teachings may be employed with memory devices transmitting in bands of the electromagnetic spectrum other than radio frequency, although one skilled in the art will note that the disclosure is particularly suited to omnidirectional transmissions. The methods and apparatus may employ symbologies other than bar code symbols, such as stacked symbols and area symbols. Other methods of logically relating the symbol identifier and the memory device identifier may be employed, such as a lookup table, or an encryption scheme such as a public and private key encryption. RF tags and methods of relating RF tags and machine-readable symbols are discussed in U.S. patent application Ser. No. 09/064,886, filed Apr. 20, 1998; and U.S. patent application Ser. No. 09/021,608, filed Feb. 10, 1998, each of which are commonly assigned and incorporated herein by reference. Systems and methods for group selection are taught in U.S. Pat. No. 5,673,037, issued Sep. 30, 1997 and incorporated herein by reference.

These and other changes can be made to the invention in light of the above detailed description. In general, in the following claims, the terms used should not be construed to limit the invention to the specific embodiments disclosed in the specification and the claims, but should be construed to include all readers and memory devices that operate in accordance with the claims to provide an apparatus or a method for associating data with a specific memory device or item. Accordingly, the invention is not limited by the disclosure, but instead its scope is to be determined entirely by the following claims.

What is claimed is:

1. A system for storing and retrieving data comprising:

a radio frequency tag having a memory for storing data;

a first identifier stored in the memory of the radio frequency tag; and

a machine readable symbol associated with the radio frequency tag, at least a portion of the machine readable symbol encoding a second identifier logically associable with the first identifier.

2. The system of claim **1** wherein the machine readable symbol is physically associated with the radio frequency tag.

3. The system of claim **1** wherein the machine readable symbol is carried by the radio frequency tag.

4. The system of claim **1** wherein the machine readable symbol is carried by a container and the radio frequency tag is carried by the container.

5. The system of claim **1** wherein the machine readable symbol and the radio frequency tag are carried by a container and the radio frequency tag stores data related to a contents of the container.

6. The system of claim **1** wherein the machine readable symbol and the radio frequency tag are carried by a container and the radio frequency tag stores data related to a destination of the container.

* * * * *

CERTIFICATE OF SERVICE

I, Rodger D. Smith II, hereby certify that on April 20, 2005 I caused to be electronically filed the Amended And Supplemental Complaint For Patent Infringement with the Clerk of the Court using CM/ECF, which will send notification of such filing to the following:

Karen L. Pascale, Esquire
Bouchard, Margules & Friedlander
222 Delaware Avenue
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